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PHYSICAL EDUCATION.

By FELIX L. OSWALD, M. D.

CLOTHING.

"No better traveling habit than *hardy habits*."—Sir Samuel Baker.

THE capacity of our ancestors to accommodate themselves to every climate depended not only on their physiological faculty of adaptation, but also on their skill in protecting themselves by artificial means from the inclemency of the higher latitudes. Houses and clothes are a blessing if they answer this purpose by a close imitation of Nature's own plan in sheltering her children from atmospheric vicissitudes; but in degree as they deviate from that plan their hygienic disadvantages balance, or even outweigh, the gain in other respects. A swallow's nest protects her brood from cold and rain without debarring them from the fresh air; a human domicile, too, should combine comfort with the advantage of perfect ventilation; and our clothes, like the fur of a squirrel or the feather-mantle of a hawk, should keep us warm and dry without interfering with the cutaneous excretions and the free movement of our limbs.

Measured by these standards, the winter dress of an American schoolboy is nearly the best, the summer dress of the average American, French, and German nursling about the worst that could possibly be devised. At an age when the rapid development of the whole organism requires the utmost freedom of movement, our children are kept in the fetters of garments that check the activity of the body in every way: swaddling-clothes, undershirts, overshirts, neck-wrappers, trailing gowns, garnitures, flounces, and shawls reduce the helpless *homunculus* to a bundle of dry-goods, unable to move or turn, incapable of relieving or intimating its uneasiness in any way save by the

use of its squealing apparatus, and consequently squealing violently from morning till night. Out-doors, in the baby-carriage, "cold draughts" have to be guarded against, and a load of extra wrappers completely counteract the benefit of the fresh air; faint with nausea and suffocating heat the little mummy lies motionless on its back, resplendent in its white surplice, a fit candidate for the honors of a life whose every movement of a natural impulse will be suppressed as a revival of barbarism and an insurrection against the statutes of an orthodox community. Hence, in a great degree, the disproportionate mortality, in all northern countries of Christendom, among infants under two years. In Spanish America, where infantile diseases are as rare as in Hindostan, babies of all classes and all sizes toddle about *naked*, nearly the year round; and the Indians of Tamaulipas, between Tampico and Matamoras, raise an astonishing number of brown bantlings who are never troubled with clothes till they are big enough to carry garden-stuff to a city where the police enforces the apron regulation.

But Mrs. Grundy—a person's pinafore—and the carpet? Well, get a lot of short linen hose, rather loose about the hips and tied around the waist or buttoned to the skirts of a short frock. Change them as often as you like. Wholesale they could be made for a dollar and washed for a quarter a dozen. Out-doors add a pair of stockings with canvas soles, and perhaps little rubber boots on wet days, but no cap or shawl before October, and under no circumstances any swaddles or baby night-gowns. Let us get rid of the "draught" superstition; catarrhs are not taken by any creature of the open air, not by the fisherman's boy, paddling around in the surf and sitting barefooted in a wet canoe or bareheaded on the windward cliffs, but by the cachectic cadets of the tenement-barracks, where the same air is breathed and rebreathed by the diseased lungs of a regiment of voluntary prisoners.*

After the first frost, a cap with ear-flaps, double stockings, and mittens out-doors can do no harm. A warm shirt and two quilt-blankets will be enough in all but the coldest nights, and (if I had not seen the thing done I should commit an outrage on common-sense by thinking it necessary to mention it) the face of a sleeping child should never be covered with a shawl, nor—when flies are very troublesome—with anything thicker than the lightest gauze handkerchief. "A great store of clothes," says Lord Bacon, "either upon the bed or the back, relaxes the body"; and every observant parent must have noticed that school-children complain a hundred times of being overdressed for once that they ask for additional or warmer clothing. Indeed, only dire habit can reconcile us to the mass of trappings and wrappings

* "I shall not attempt to explain why 'damp clothes' occasion colds rather than wet ones, because I doubt the fact. I imagine that neither the one nor the other contributes to this effect, and that the causes of colds are totally independent of wet and even of cold."—(Ben Franklin's "Essays," p. 216.)

which fashion and effeminacy load us with. Five hundred millions of our fellow-men wear scarcely any clothing—not in Africa and Southern Asia only, but in cold Patagonia and the by no means genial latitudes of the Norfolk Islands. The mantle of the Roman peasant was laid aside in cold weather and generally at the beginning of the day's work. The sculptures of Rome and Greece abound with the representations of nude hunters, shepherds, and artisans. On the friezes of Pompey and the countless vases and entablatures of the Museo Borbonico and the Vatican collection, children, almost without any exception, appear *in naturalibus*. The very word *gymnasium* was derived from γυμνός, *naked;* and there is every reason to believe that the *toga virilis*, like the *toga prætexta*, was worn only on state occasions. Henry's "History of Great Britain" (vol. i, pp. 468, 469) leaves hardly any doubt that the ancient Britons, Picts, and Scots were either wholly or almost naked, "unless their custom of painting their bodies can be considered as clothing." Nor did the south Britons and Romans go naked from poverty, like Darwin's Firelanders. They had clothes, but they reserved them for emergencies, and, though our advanced notions of decency and cleanliness might not permit us to emulate their example, I suspect that, from May to November, the lightest suit of clothes is, from an hygienic standpoint, about the best. The body breathes through the pores as well as through the lungs, and heavy garments obstruct the cutaneous exhalations quite as much as the atmosphere of an overheated room impedes the process of respiration, and it has been found by actual experiments that the weight of a mantle or heavy coat with woolen shirts and other underwear diminishes the respiratory capacity of the lungs from twenty to twenty-five per cent.—(Coale's "Hints on Health," p. 104.)

Besides, it seems that fresh air exercises on the human skin a certain tonic influence, of which the wearer of thick woolen garments deprives his body. Benjamin Franklin proposed to prevent colds, and even small-pox, by *air-baths*, and found that he could relieve insomnia by simply removing the bedclothes for a couple of minutes. "I rise early almost every morning," says he, "and sit in my chamber without any clothes whatever, half an hour or an hour, according to the season, either reading or writing. This practice is not the least painful but, on the contrary, agreeable, and if I return to bed afterward, before I dress myself, as it sometimes happens, I make a supplement to my night's rest of one or two hours of the most pleasing sleep that can be imagined."—("*A New Mode of Bathing*," Franklin's "Essays," p. 215.)

Nor should we forget the incidental advantages of hardy habits, their invigorating influence on the constitution in general and on the digestive system in particular, nor the fact that effeminacy defeats its own object and exposes its slaves to sufferings unknown to the sons of the wilderness. He who restricts himself to a minimum of clothes in

summer-time will find an extra shirt or a plaid and a pair of mittens a sufficient protection from almost any weather. The Indians of the Tehuantepec highlands, who work the year round in a breech-clout and a palmetto hat, ascend the icy summit regions of the Sierra Madre with a threadbare blanket as their only cover from cold winds and night frosts; and our own red-skins prefer an old-buffalo robe to the best tight-fitting garments, and invariably tear the seams of the store-clothes they buy at the post-agencies—to make them "lighter," ventilate them, as it were. Nay, the post-trader of Fort Richardson, on the upper Brazos, assured me that his Kiowa customers never bought a suit of clothes without cutting the seat out of the pantaloons and slitting the coats from the armpits down to the skirts!

If an out-door laborer leaves a warm house on a cold morning, the first contact with the open air is anything but agreeable, but after half an hour's exercise the body warms up from within, and this animal caloric can make a heavy suit of clothes as oppressive in winter as in midsummer; the gaseous excretions of the skin, after saturating the confined air, are condensed and thus effectually checked—the body has to forego the benefits of cutaneous respiration. And herein consists the difference between our artificial fleece and the hairy coat of a wild beast: fur and wool retain the animal warmth but emit the cutaneous vapors; a close woven coat stops both. The process of tanning, too, stops the pores of the fur-skin, and I have often wondered why our dress-reformers have never tried to construct a fur coat on the brush-maker's plan—fastening the hair in little bunches on some strong, net-like texture. By spreading outward, the hair would present the even surface of the natural fur, and make such a porous brush coat nearly as warm as a common pelisse. Thus far the same end has been most nearly attained by the triple blouse of the Havre 'longshoremen—three linen jackets; the first and third as smooth as a shirt, but the middle one *ruffled*, i. e., gathered up in a series of open plaits like a mediæval lace collar. This arrangement prevents a "tight fit," and leaves a considerable space on both sides of the middle blouse, and, air being a bad conductor, the three blouses, weighing about three pounds apiece, are actually warmer than a twelve-pound overcoat of thick broadcloth, but fitting the back like the cover of a pin-cushion. On going to work, the *porte-faix* removes one or two of his blouses, according to the state of the weather, as the American schoolboy takes off his comforter and unbuttons his jacket before going in for a snow-ball fight.

A jacket or a short blouse is out and out more sensible than our cumbersome overcoats or the unspeakable tangle-work of frippery and flounces, cross-and-lengthwise wrappings, and intricate fastenings that still form the winter dress of a fashionable lady. The women of Scandinavia and New England (Jenny Lind, Mrs. Everett, Dr. Mary Safford-Blake, etc.) can claim the honor of having initiated the oppo-

sition movement that bids fair to abate the grievance in the course of another generation or two, having already exploded the chief outrages on hygienic and artistic common-sense—corsets and the crinoline. Mrs. Abba G. Woolson's "Dress Reform" should be the sartorial text-book of every girl's mother.

The Turks and Hollanders, though differing so widely in their general mode of life, agree in preferring warm clothes to heated rooms, and when the in-door atmosphere can be made tolerable only by air-tight window-sashes and glowing stoves, it is a curious question whether a warmer dress would not, on the whole, be the lesser evil. It would save fuel, sick-headaches, and constipation, and by adding or removing an extra blouse, *à la Normandie*, the several occupants of a moderately warmed room might exactly adapt the temperature to their individual feelings. A German author, who admits hardly any excuse for excluding the fresh air from a sitting-room, proposes an ingenious remedy for *cold hands*—the only cogent objection to an open study-window: a box writing-desk, namely, with a double lid, the writing-board resting on top of a box full of hot sand, that can be warmed in a common baking-pan and warranted to retain its heat for five or six hours. A cold garret library was Goethe's favorite refuge from sick-headaches; and the Chevalier Edelkranz reminds his fur-loving countrymen that, when the difference of temperature between the external air and that within-doors is inconsiderable, it would be useful to "put on an extra coat on *returning* home, instead of doing it when going out, since the exercise in the open air produces the necessary degree of warmth, which, in the chamber, in a sedentary state, can only be supplied by additional clothing."

In our climate, however, there are days when a child of the Caucasian race has urgent need of all the overcoats his shoulders can support, and the natives of northern Michigan have taught their Saxon neighbors some useful lessons in the art of surviving a Lake Superior snow-storm. Experience has made them eschew our common head-gear; they wear "Mackinaw hoods," a sort of monk's cowl, buttoned to the mantle-collar and covering every part of the face but the eyes and a small space between the mouth and the nostrils; double woolen mittens, reaching half-way up to the elbow; baggy trousers, fastened around the ankle, and shoes that admit three or four pairs of worsted stockings. Their particular care seems to be to protect the neck, hands, and feet; and it might, indeed, be accepted as a general rule that the parts of the body farthest from the heart are most liable to suffer from the effects of a low temperature. All extremities—toes, fingers, nose, and ears—are especially apt to get frost-bitten, but marching against a cold wind also produces a peculiarly uncomfortable sensation about the *neck*, and I can not help thinking that there is something wrong about our fashion of cropping our boys like criminals. A good head of hair may be something more than an ornamental

appendage, and Nature seems to have taken especial care to protect the nape of the neck in a great number of different animals. It is certainly a suggestive circumstance that fomenting the space between the shoulders exerts an assuaging effect on various affections of the respiratory organs; and, if I had the care of a boy with an hereditary disposition to a pulmonary disease, I should feel strongly tempted to defy fashion, and let him wear his hair *à la Guido*—about a foot long.

The canal-laborers of Sault Ste. Marie wear double hoods, and on many days have to stuff them with wool to save their ears; but, in the more populous part of America, such days are a rare exception, and south of the lower lakes the average schoolboy will prefer to rough it with a tippet shawl or a common cap with a pair of ear-flaps. In regard to the utility of woolen underclothes, opinions are much divided: Carl Bock recommends worsted jackets; Dr. Coale flannel undershirts and drawers, with extra breast-pads in cold weather; but the hardy Scandinavians, Russians, and French Canadians, as well as the great majority of our German population, still stick to coarse linen next the skin, and use woolen pectorals only as counter-irritants in rheumatic affections. Persons who can not bear woolen underclothes, I would advise to try the Normandy plan of ruffled linen, which might be applied even to hoisery and drawers. Chamois-leather, too, is as warm as wool and less irritating to the skin, and has the advantage of being more durable, and withal cleanlier, than the best flannel. On stormy days, especially during the piercing northwest storms of our prairie States, few children will object to a Scotch plaid, worn like a burnoose, over head and shoulders, or a handful of wool stuffed around the socks in a pair of wide brogans.

But at the beginning of the warm season all such things ought to be thrown aside. A loose shirt, linen jacket, and short linen trowsers are the right summer dress for a healthy boy—a dalmatica and light straw hat for a healthy girl—in a country where the six warmest months approach the isotherms of southern Spain. No wadded coats, no drawers, and, in the name of reason, no flannels, nor shoes and stockings, unless the mud is very deep, or the road to school recently macadamized. The long-lived races of Eastern Europe would laugh at the idea that the constitution of a normal human being could be endangered by an April shower, or that in the dog-days "health and decency" require a woolen cuticle from neck to foot. Have dogmas and hearsays entirely closed our senses to the language of instinct, to the meaning of the discomfort, the distracting uneasiness under the burden of a load of calorific covers and bandages, while every pore of our skin cries out for relief, for the cooling influence of the free open air? Keep your children under lock and key, lest the sun should spoil their complexion or their morals, let them pass their days in an underground dungeon like Kaspar Hauser, but do not load

them with woolen trappings at a time when even a linen robe becomes a Nessus-shirt. There is a story of a glutton being cured by a friend who persuaded him to eat and drink nothing for twenty-four hours without putting an equivalent in quantity and quality into an earthen crock, and the next day made him inspect the *collectanea ;* and on the same principle a person of common-sense might perhaps be redeemed from the slavery of the dress-mania, by making him wrap up his complete suit of traps and weigh the bundle : he would find that the summer dress of a fashionable gentleman outweighs the winter coat of the most hirsute brute of the wilderness. A grizzly bear, shorn to the skin, would yield about ten pounds of hair and wool ; but a dandy's accoutrements—flannel undershirt, drawers, shoes, stockings, starched overshirt, waistcoat, cravat, black dress-coat, and pantaloons—would weigh at least fourteen pounds. Habit mitigates the evil, though there are times when the martyrs of fashion suffer more in a single hour than a ragged Comanche in the coldest winter week ; but, for boys and young girls, calorific food and woolen clothes certainly make the sunniest days the saddest in the year.

The vicissitudes of the weather? It is worth a journey to Trieste to see the youngsters of the suburbs enjoy their evenings on the Capo Liddo, the sandy headland between the Pola pike-road and the harbor fortifications : four or five hundred half-wild boys, splashing in the surf, throwing stones, wrestling, or chasing each other along the shore, all shouting and cheering, merry as carnivallers, though there is not a pair of shoes or a dozen hats in the crowd. Swift-footed, lithe, and indefatigable, they are the very picture of careless health ; you can see them at play almost every evening, even in winter, when the *Tramontane* raises the snow-drifts of the Karst. They laugh at summer showers ; their linen jackets will dry before they get home. Sunshine makes them a holiday ; but let your well-dressed New York or Paris schoolboy join in their sports, and examine his clothes after an hour or two, and see if perspiration has not made his undershirts as wet as any rain could make his jacket.

Decency? Are the gambols of a barefoot boy more unseemly than the contortions of a sunstruck alderman in his holiday dress? Can ethics or æsthetics be promoted by the imprecations of a sleepless victim of flannel night-shirts and closed bedroom windows? If daily misery can spoil the temper of a saint, the ladies of the American Dress-Reform are working in the interest of charity and good-humor by removing a chief incentive to the opposite sentiments, for the aggravations of Tantalus must have been trifling compared with those of an American schoolgirl *à la mode*, at the thought of a mountain meadow to run on with naked feet or a shady brook to pick pebbles from with bared arms. Pocahontas, indeed, had no need to envy the "fair maids in the land of her lover," if the fair ones had to wear the twenty-three distinct pieces of dry-goods which, according to a cor-

respondent of Virchow's "Jahresberichte," constitute the summer dress of the average girl of the period. The blind submission to such demands of fashion can be explained only by a long subjection of human reason to authority, together with that ridiculous *dread of nudity* which forms a characteristic feature of all anti-natural religions. According to the ethics of the Hebrew-Buddhistic moralists, all *naturalia sunt turpia;* the body is the arch-enemy of the soul, and must be hidden, lest the children of the Church might be reminded of their relationship to the despised children of Nature. Boys and girls have no vote in such matters, or they would consent to turn night into day for the sake of getting a little exercise without the dire alternative of sweating to death or awakening the anathemas of Mrs. Grundy. The misery reaches its climax in June, when the warm weather begins before the vacations; and in midsummer a person with humane instincts would rather make a wide *détour* than pass a town school or a cotton-factory and witness the triumph of our pious civilization—the daily and intolerable torture of thousands of helpless children to please an Old Hypocrites' Christian Association of priests and prudes!

As houses have been called exterior garments, a heavy suit of clothes might be called a portable house—a protective barrier between the skin and the cold air; but in warm weather the most effectual device for diminishing the benefit of out-door exercise. Between May and October man has to wear clothes enough to keep the flies and gnats from troubling him: a pair of linen trowsers, a shirt, and a light neckerchief—whatsoever is more than these is of evil. The best head-dress for summer is our natural hair; the next best a light straw hat, with a perforated crown. Hats and caps, as a protection from the vicissitudes of the atmosphere, are a comparatively recent invention. The Syrians, Greeks, Romans, Normans, and Visigoths wore helmets in war, but went uncovered in time of peace, in the coldest and most stormy seasons; the Gauls and Egyptians always went bareheaded, even into battle, and, a hundred years after the conquest of Egypt by Cambyses (B. C. 525), the sands of Pelusium still covered the well-preserved skulls of the native warriors, while those of the turbaned Persians had crumbled to the jawbones. The Emperor Hadrian traveled bareheaded from the icy Alps to the borders of Mesopotamia; the founders of several monastic orders interdicted all coverings for the head; during the reign of Henry VIII, boys and young men generally went with the head bare, and to the preservation of this old Saxon custom Sir John Sinclair* ascribes the remarkable health of the orphans of Queen's Hospital. The human skull is naturally better protected than that of any other warm-blooded animal, so that there seems little need of adding an artificial covering; and, as Dr. Adair observes, the most neglected children, street Arabs and young gypsies, are least

* "Code of Health and Longevity," p. 298.

liable to diseases, chiefly because they are not guarded from the access of fresh air by too many garments (Adair's "Medical Cautions," p. 389). It is also well known that baldness is the effect of effeminate habits as often as of dissipation; and yet there are parents who think it highly dangerous to let a boy go out bareheaded even in May or September. The trouble is, that so many of our latter-day health codes are framed by men who mistake the exigencies of their own decrepitude for the normal condition of mankind. Thousands of North American mothers get their hygienic oracles from the household notes of some orthodox weekly, where the Rev. Falstaff Tartuffe assures them—from personal experience—that raw apples are indigestible, and that rheumatism can be prevented only by nightcaps and woolen undershirts.

Girls, it seems, have to pass through a millinery climacteric, as their brothers through a wild-oats period; but even during that interregnum of reason the instinct of self-preservation would assert its supremacy if the health laws of physiology and their antagonism to certain fashions were more generally understood. Claude Bernard speaks of a French philanthropist who proposed to offer a prize for the most tasteful female dress, manufactured from the cheapest materials; and, if the votaries of the Graces would consent to a reform in the shape and stuff of their garments, we could well afford to indulge them in chromatics and a flounce or two, for there is no reason to afflict them with Quaker-drab, if more cheerful colors are as cheap. As long as they avoid excesses in the quantity and form of their dress, and restrict themselves to four dimes' worth of vanities per month, we need not grudge them a display of their taste in the selection of pretty patterns; let them radiate in all the colors of the rainbow and all the gems of the "Chicago Prize-Package Company." *Veniunt a veste sagittæ*—the dress problem has always employed the leisure of gossips and Doctors' Commons, especially in cities, and more especially in the wealthy and indolent cities of the Old World. There is a legend of a New England virgin fainting at the mention of "undressed lumber," but that tradition must be of Eastern origin. The dry-goods worship is carried nowhere further than where children are treated like dolls and women like children, unfit to be intrusted with any more important business. The "organ of ornamentativeness," or fashion-mania, may, after all, not be an innate instinct of the female mind. Madame de Staël and Mrs. Lewes at least deny it, and, if they are right, an enlarged sphere of activity will by-and-by help their sisters to outgrow that bias. In the mean while, the best palliative is a liberal education, besides a zealous propaganda of the two chief theses of the *dress reform:* wider jackets and shorter under-garments; no trailing dresses, keeping the feet wet and impeding locomotion; no stays, corsets, and strait-jacket bodices.

Next to the regulation dress of the Turner hall, the present style

of the United States infantry uniform is about the most sensible that could be devised with regard to sanitary advantages, and nearly so in respect to good taste, if Thorwaldsen's dictum holds good, that the most becoming garments are those which adapt themselves to the natural outlines of the human form. A jacket should be loose, with wide but rather short sleeves, loose trousers, no waistcoat or drawers in the summer season; for small boys, short trousers without pockets, but with broad leather braids along the seams. The comparative advantages of waistbands or braces have been frequently controverted; at best it is only a question of choosing the lesser evil. A tight belt is almost as injurious as a corset, while non-elastic suspenders may interfere with the functions of the respiratory organs, and even occasion stooping. For boys and slender-built men, with well-developed hips, an elastic waistband is, on the whole, preferable; corpulent persons can not dispense with braces, for the plan of buttoning the breeches to the jacket or waistband would amount to the same, by making the shoulders support the weight of the lower garments. Tight breeches have, fortunately, gone out of fashion; likewise tight kid-gloves, which were once *de rigueur* on every public promenade.

But we all sin against our feet; not one white man in ten thousand wears shoes that are not more or less of a hindrance in walking, and often a source of wretched discomfort. In the United States, England, and Central Europe, it is wholly impossible to find a ready-made pair of shoes to fit a normal human foot; they are all too tight in proportion to their length, every pair of them, even the United States army shoes and the English "fast-walking brogans." Heels are nonsense; there is no excrescence on the sole of a well-formed human being. A man can walk faster, more easily, and more gracefully, with level shoes, with soles shaped like those of a slipper or an Indian moccasin. An easy shoe should be heelless; the upper leather soft and pliable; the sole of a No. 9 shoe at least four inches wide. But you can not persuade a shoemaker to commit such heresies against the tenets of his craft. Dio Lewis recommends paper patterns, corresponding to the exact shape of the natural sole, but it is all in vain; a compromise between reason and dogma is the best you can attain by such means. The only practicable plan is to get one pair of shoes made under your personal supervision, and then stipulate for the necessary number of precise *fac-similes*. The disciple of St. Crispin shrinks from the guilt of the original sin, but connives at a copy; a precedent will reconcile his conscience.

For children there is a shorter expedient: let them go barefoot, at least in-doors and all summer; it will make them hardier and healthier. Abernethy, Schrodt, Dr. Adair, Jean Jacques Rousseau, and Claude Bernard, agree on this point; Dr. Cadogan thinks shoes and stockings wholly useless, and John G. Whittier seems to share his opinion that a barefoot boy is the happiest representative of the human species. "I

can see no reason why my pupil should always have a piece of ox-hide under his foot," says the author of "Emile." . . . "Let him run barefoot wherever he pleases. . . . Far from growling about it, I shall imitate his example." *

Refusing to buy tight shoes might bring easy ones into fashion; but boys are better off without them, especially in the years of rapid growth, when their measure changes from month to month, for too wide shoes are as uncomfortable as tight ones. Out-doors, children's stockings are almost sure to get wet, and keep the feet clammy and cold; while a young gypsy or a Scotchman, inured to wind and weather, treads with his bare feet the swampiest valleys and the roughest hill-roads without the least discomfort. Nature produces a better sole-leather than any shoemaker; the tegument of a raccoon's foot or a monkey's hind-hand can give us an idea of the marvels of her workmanship. The sole of a plantigrade animal is not hard; on the contrary, quite pliable and soft to the touch, but withal *tougher* than any caoutchouc, impervious alike to water, sand, and thorns. A camel, too, has a foot of that sort—pads that resist the burning gravel of the desert for years, where a horse's hoof would wear out in a few weeks; for the same reason that a "sand-blast" destroys tanned sole-leather and horn, but hardly affects the elastic skin of the human hand. Millions of unshod Hindoos, negroes, and South American savages, brave the jungles of the tropical virgin woods; and in Nicaragua I saw two Indian mail-carriers *trot* barefoot over the lava-beds of Amilpas, over fields of obsidian and scoria, where a dandy in patent-leather gaiters would have feared to tread. Three or four seasons of barefoot rambles over the fields and hills will develop such soles—natural shoe-leather that improves from year to year, till it can be warranted to protect the wearer against the roughest roads, and, as the experience of our half-wild frontiersmen attests, also against colds and rheumatism. A mere moccasin secures such hardy feet against frost-bites; for here, too, the rule holds good that those who keep themselves too warm in the summer season deprive themselves of the advantage to be derived from additional clothing in cold weather and in old age.

Herr Teufelsdröckh devoted a voluminous work to the "Philosophy of Clothing," but the practical part of the science may be summed up in a few words. Our dress ought to be adapted to the changes of the seasons, and should be in quality durable, cleanly, and, above all, easy; in quantity, the least amount compatible with decency and comfort.

* "Pourquoi faut-il que mon élève soit forcé d'avoir toujours sous les pieds une peau de bœuf? Quel mal y aurait-il que la sienne propre pût au besoin lui servir de semelle? Il est clair qu'en cette partie la delicatesse de la peau ne peut jamais être utile à rien et peut souvent beaucoup nuire. Que Émile coure les matins à pieds nus, en toute saison, par le chambre, par l'escalier, par le jardin; loin de l'en grondir je l'imitirai."—(Rousseau: "Émile, ou de L'éducation," p. 143.)

ON FRUITS AND SEEDS.

By Sir JOHN LUBBOCK, F. R. S.

OUR eloquent countryman, Mr. Ruskin, commences his work on "Flowers" by a somewhat severe criticism of his predecessors. He reproduces a page from a valuable but somewhat antiquated work, "Curtis's Magazine," which he alleges to be "characteristic of botanical books and botanical science, not to say all science," and complains bitterly that it is a string of names and technical terms. No doubt that unfortunate page does contain a list of synonyms and long words. But, in order to identify a plant, you must have synonyms and technical terms, just as to learn a language you must have a dictionary. To complain of this would be to resemble the man who said that Johnson's "Dictionary" was dry and disjointed reading. But no one would attempt to judge the literature of a country by reading a dictionary. So also we can not estimate the interest of a science by reading technical descriptions. On the other hand, it is impossible to give a satisfactory description of an animal or plant except in strict technical language. Let me reproduce a description which Mr. Ruskin has given of the swallow, and which, indeed, he says in his lecture on that bird, is the only true description that could be given. His lecture was delivered before the University of Oxford, and is, I need hardly say, most interesting.

Now, how does he describe a swallow? "You can," he says, "only rightly describe the bird by the resemblances and images of what it seems to have changed from, then adding the fantastic and beautiful contrast of the unimaginable change. It is an owl that has been trained by the Graces. It is a bat that loves the morning light. It is the aërial reflection of a dolphin. It is the tender domestication of a trout." That is, no doubt, very poetical, but it would be absolutely useless as a scientific description, and, I must confess, would never have suggested, to me at least, the idea of a swallow.

But, though technical terms are very necessary in science, I shall endeavor, as far as I can, to avoid them here. As, however, it will be impossible for me to do so altogether, I will do my best at the commencement to make them as clear as possible, and I must therefore ask those who have already looked into the subject to pardon me if, for a few moments, I go into very elementary facts. In order to understand the structure of the seed, we must commence with the flower, to which the seed owes its origin. Now, if you take such a flower as, say, a geranium, you will find that it consists of the following parts: firstly, there is a whorl of green leaves, known as the sepals, and together forming the calyx; secondly, a whorl of colored leaves, or petals, generally forming the most conspicuous part of the flower, and called the

corolla; thirdly, a whorl of organs, more or less like pins, which are called stamens; and in the heads, or anthers, of which the pollen is produced. These anthers are in reality, as Goethe showed, modified leaves; in the so-called double flowers, as, for instance, in our garden roses, they are developed into colored leaves like those of the corolla, and monstrous flowers are not unfrequently met with in which the stamens are green leaves, more or less resembling the ordinary leaves of the plant. Lastly, in the center of the flower is the pistil, which also is theoretically to be considered as constituted of one or more leaves, each of which is folded on itself and called a carpel. Sometimes there is only one carpel. Generally the carpels have so completely lost the appearance of leaves that this explanation of their true nature requires a considerable amount of faith. The base of the pistil is the ovary, composed, as I have just mentioned, of one or more carpels, in which the seeds are developed. I need hardly say that many so-called seeds are really fruits; that is to say, they are seeds with more or less complex envelopes.

We all know that seeds and fruits differ greatly in different species. Some are large, some small; some are sweet, some bitter; some are brightly colored; some are good to eat, some poisonous, some spherical, some winged, some covered with bristles, some with hairs, some are smooth, some very sticky.

We may be sure that there are good reasons for these differences. In the case of flowers much light has been thrown on their various interesting peculiarities by the researches of Sprengel, Darwin, Müller, and other naturalists. As regards seeds also, besides Gärtner's great work, Hildebrand, Krause, Steinbrinck, Kerner, Grant Allen, Wallace, Darwin, and others, have published valuable researches, especially with reference to the hairs and hooks with which so many seeds are provided, and the other means of dispersion they possess. Nobbe also has contributed an important work on seeds, principally from an agricultural point of view, but the subject as a whole offers a most promising field for investigation. It is rather with a view of suggesting this branch of science to you, than of attempting to supply the want myself, that I now propose to call your attention to it. In doing so I must, in the first place, express my acknowledgments to Mr. Baker, Mr. Carruthers, Mr. Hemsley, and especially to Mr. Thiselton Dyer and Sir Joseph Hooker, for their kind and most valuable assistance.

It is said that one of our best botanists once observed to another that he never could understand what was the use of the teeth on the capsules of mosses. "Oh," replied his friend, "I see no difficulty in that, because, if it were not for the teeth, how could we distinguish the species?"

We may, however, no doubt, safely consider that the peculiarities of seeds have reference to the plant itself, and not to the convenience of botanists.

In the first place, then, during growth, seeds in many cases require protection. This is especially the case with those of an albuminous character. It is curious that so many of those which are luscious when ripe, as the peach, strawberry, cherry, apple, etc., are stringy and almost inedible till ripe. Moreover, in these cases, the fleshy portion is not the seed itself, but only the envelope, so that even if the sweet part is eaten the seed itself remains uninjured.

On the other hand, such seeds as the hazel, beech, Spanish chestnut, and innumerable others, are protected by a thick, impervious shell, which is especially developed in many *Proteaceæ*, the Brazil-nut, the so-called monkey-pot, the cocoanut, and other palms.

In other cases the envelopes protect the seeds, not only by their thickness and toughness, but also by their bitter taste, as, for instance, in the walnut. The genus *Mucuna*, one of the *Leguminosæ*, is remarkable in having the pods covered with stinging hairs.

In many cases the calyx, which is closed when the flower is in bud, opens when the flower expands, and then after the petals have fallen closes again until the seeds are ripe, when it opens for the second time. This is, for instance, the case with the common herb-robert (*Geranium Robertianum*). In *Atractylis cancellata*, a South European plant, allied to the thistles, the outer envelopes form an exquisite little cage. Another case, perhaps, is that of *Nigella*, the "Devil-in-a-bush," or, as it is sometimes more prettily called, "Love-in-a-mist," of old English gardens.

Again, the protection of the seed is in many cases attained by curious movements of the plant itself. In fact, plants move much more than is generally supposed. So far from being motionless, they may almost be said to be in perpetual movement, though the changes of position are generally so slow that they do not attract attention. This is not, however, always the case. We are all familiar with the sensitive-plant, which droops its leaves when touched. Another species (*Averrhoa bilimbi*) has leaves like those of an acacia, and all day the leaflets go slowly up and down. *Desmodium gyrans*, a sort of pea living in India, has trifoliate leaves, the lateral leaflets being small and narrow ; and these leaflets, as was first observed by Lady Monson, are perpetually moving round and round, whence the specific name *gyrans*. In these two cases the object of the movement is quite unknown to us. In *Dionœa*, on the other hand, the leaves form a regular fly-trap. Directly an insect alights on them they shut up with a snap.

In a great many cases leaves are said to sleep ; that is to say, at the approach of night they change their position, and sometimes fold themselves up, thus presenting a smaller surface for radiation, and being in consequence less exposed to cold. Mr. Darwin has proved experimentally that leaves which were prevented from moving suffered more from cold than those which were allowed to assume their natural position. He has observed with reference to one plant, *Maranta arundi-*

nacea, the arrow-root, a West Indian species allied to *Canna*, that if the plant has had a severe shock it can not get to sleep for the next two or three nights.

The sleep of flowers is also probably a case of the same kind, though, as I have elsewhere attempted to show, it has now, I believe, special reference to the visits of insects; those flowers which are fertilized by bees, butterflies, and other day insects, sleep by night, if at all; while those which are dependent on moths rouse themselves toward evening, as already mentioned, and sleep by day. These motions, indeed, have but an indirect reference to our present subject. On the other hand, in the dandelion (*Leontodon*), the flower-stalk is upright while the flower is expanded, a period which lasts for three or four days; it then lowers itself and lies close to the ground for about twelve days, while the fruits are ripening, and then rises again when they are mature. In the *Cyclamen* the stalk curls itself up into a beautiful spiral after the flower has faded.

The flower of the little *Linaria* of our walls (*L. cymbalaria*) pushes out into the light and sunshine, but as soon as it is fertilized it turns round and endeavors to find some hole or cranny in which it may remain safely ensconced until the seed is ripe.

In some water-plants the flower expands at the surface, but after it is faded retreats again to the bottom. This is the case, for instance, with the water-lilies, some species of the *Potamogeton* (*Trapa natans*). In *Valisneria*, again, the female flowers (Fig. 1, *a*) are borne on long stalks, which reach to the surface of the water, on which the flowers float. The male flowers (Fig. 1, *b*), on the contrary, have short, straight stalks, from which, when mature, the pollen (Fig. 1, *c*) detaches itself, rises to the surface, and, floating freely on it, is wafted about, so that it comes in contact with the female flowers. After fertilization, however, the long stalk coils up spirally, and thus carries the ovary down to the bottom, where the seeds can ripen in greater safety.

The next points to which I will direct your attention are the means of dispersion possessed by many seeds. Farmers have found by experience that it is not desirable to grow the same crop in the same field year after year, because the soil becomes more or less exhausted. In this respect, therefore, the powers of dispersion possessed by many seeds are a great advantage to the species. Moreover, they are also advantageous in giving the seed a chance of germinating in new localities suitable to the requirements of the species. Thus a common European species, *Xanthium spinosum*, has rapidly spread over the whole of South Africa, the seeds being carried in the wool of sheep. From various considerations, however, it seems probable that in most cases the provision does not contemplate a dispersion for more than a short distance.

There are a great many cases in which plants possess powers of movement directed to the dissemination of the seed. Thus, in *Geas-*

trum hygrometricum, a kind of fungus which grows underground, the outer envelope—which is hard, tough, and hygrometric—divides, when mature, in strips from the crown to the base; these strips spread horizontally, raising the plant above its former position in the ground; on rain or damp weather supervening the strips return to their former

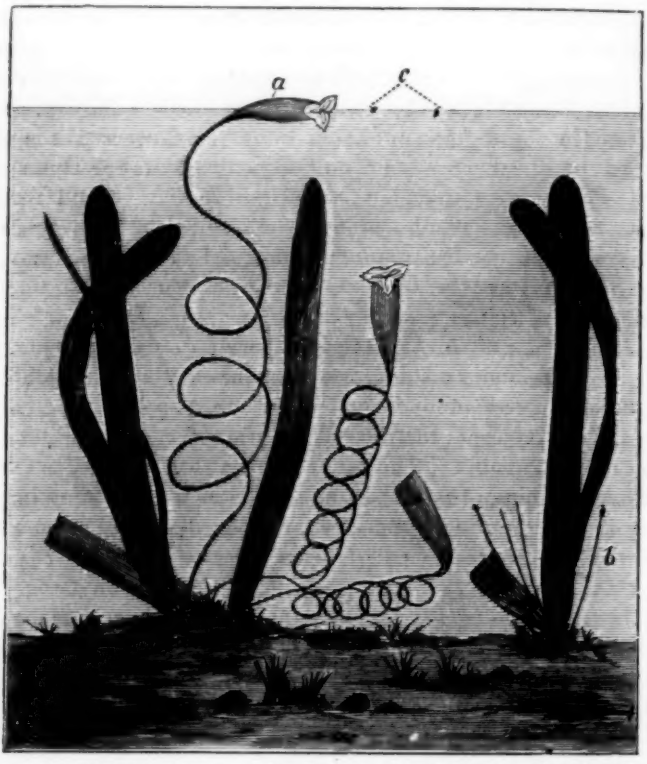

FIG. 1.—VALISNERIA SPIRALIS. *a*, female flower; *b*, male flower; *c*, floating pollen.

position; on the return of the drought this process is repeated, until the fungus reaches the surface and spreads out there; then the membrane of the conceptacle opens and emits the spores in the form of dust.

I have already referred to the case of the common dandelion. Here the flower-stalk stands more or less upright while the flower is expanded, a period which generally lasts for three or four days. It then lowers itself, and lies more or less horizontally and concealed during the time the seeds are maturing, which in our summers occupies about twelve days. It then again rises, and, becoming almost erect, facilitates the dispersion of the seeds, or, speaking botanically, the fruits, by the wind. Some plants, as we shall see, even sow their seeds in the ground, but these cases will be referred to later on.

In other cases the plant throws its own seeds to some little distance. This is the case with the common *Cardamine hirsuta*, a little plant, I do not like to call it a weed, six or eight inches high, which comes up of itself abundantly on any vacant spot in our kitchen-gardens or shrubberies, and which much resembles that represented in Fig. 17, but without the subterranean pods *b*. The seeds are contained in a pod which consists of three parts, a central membrane, and two lateral walls. When the pod is ripe the walls are in a state of tension. The seeds are loosely attached to the central piece by short stalks. Now, when the proper moment has arrived, the outer walls are kept in place by a delicate membrane, only just strong enough to resist the tension. The least touch, for instance a puff of wind blowing the plant against a neighbor, detaches the outer wall, which suddenly rolls itself up, generally with such force as to fly from the plant, thus jerking the seeds to a distance of several feet.

FIG. 2.—VIOLA HIRTA. *a*, young bud; *b*, ripe seed-capsule.

In the common violets, besides the colored flowers, there are others in which the corolla is either absent or imperfectly developed. The stamens also are small, but contain pollen, though less than in the colored flowers. In the autumn large numbers of these curious flowers are produced. When very young they look like an ordinary flower-bud (Figs. 2 and 3, *a*), the central part of the flower being entirely covered by the sepals, and the whole having a triangular form. When older (Figs. 2 and 3, *b*) they look at first sight like an ordinary seed-capsule, so that the bud seems to pass into the capsule without the flower-stage. The pansy violets do not possess these interesting flowers. In the sweet-violet (*Viola odorata* and *Viola hirta*, Fig. 2) they may easily be found by searching among the leaves nestling close to the ground. It is often said, for instance by Vaucher, that the plants actually force these capsules into the ground, and thus sow their own seeds. I have not, however, found this to be the case, though, as the stalk elongates, and the point of the capsule turns downward, if the earth be loose and uneven, it will no doubt sometimes so happen.

When the seeds are fully ripe, the capsule opens by three valves and allows them to escape.

In the dog-violet (*Viola canina*, Fig. 3) the case is very different. The capsules are less fleshy, and, though pendent when young, at

FIG. 3.—VIOLA CANINA. *a*, bud; *b*, bud more advanced; *c*, capsule open, some of the seeds are already thrown.

maturity they erect themselves (Fig. 3, *c*), stand up boldly above the rest of the plant, and open by the three equal valves (Fig. 4) resembling an inverted tripod. Each valve contains a row of three, four, or five brown, smooth, pear-shaped seeds, slightly flattened at the upper,

FIG. 4.

FIG. 5.—VIOLA CANINA; SEED-VESSEL AFTER EJECTING THE SEEDS.

wider end. Now the two walls of each valve, as they become drier, contract, and thus approach one another, thus tending to squeeze out the seeds. These resist some time, but at length the attachment of

the seed to its base gives way, and it is ejected several feet, this being no doubt much facilitated by its form and smoothness. I have known even a gathered specimen throw a seed nearly ten feet. Fig. 5 represents a capsule after the seeds have been ejected.

Now, we naturally ask ourselves what is the reason for this difference between the species of violets ; why do *Viola odorata* and *Viola hirta* conceal their capsules among the moss and leaves on the ground, while *Viola canina* and others raise theirs boldly above their heads, and throw the seeds to seek their fortune in the world? If this arrangement be best for *Viola canina*, why has not *Viola odorata* also adopted it? The reason is, I believe, to be found in the different mode of growth of these two species. *Viola canina* is a plant with an elongated stalk, and it is easy, therefore, for the capsule to raise itself above the grass and other low herbage among which violets grow.

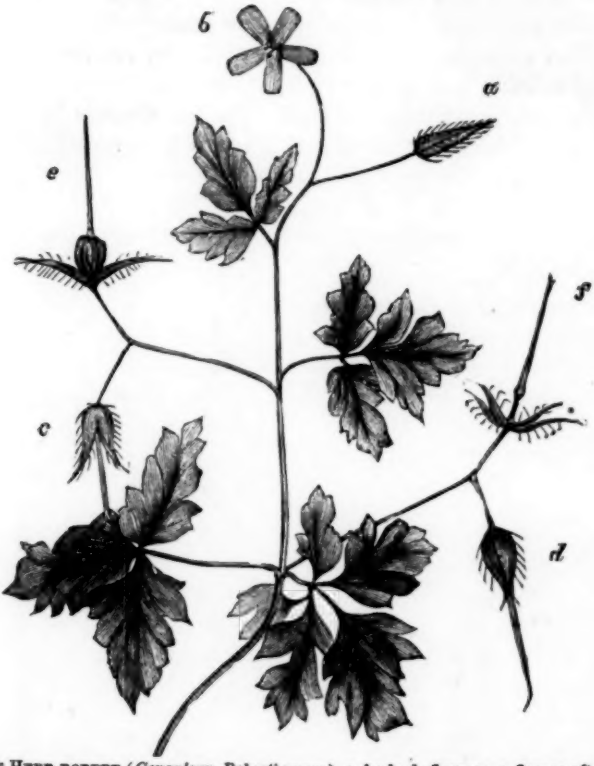

Fig. 6.—The Herb-robert (*Geranium Robertianum*,) *a*, bud ; *b*, flower ; *c*, flower after the petals have fallen ; *d*, flower with seeds nearly ripe ; *e*, flower with ripe seeds ; *f*, flower after throwing seeds.

Viola odorata and *Viola hirta*, on the contrary, have, in ordinary parlance, no stalk, and the leaves are radical, i. e., rising from the root. This is at least the case in appearance, for, botanically speaking, they rise at the end of a short stalk. Now, under these circumstances, if

the sweet violet attempted to shoot its seeds, the capsules not being sufficiently elevated, the seeds would merely strike against some neighboring leaf, and immediately fall to the ground. Hence, I think, we see that the arrangement of the capsule in each species is that most suitable to the general habit of the plant.

In the true geraniums again, as for instance in the herb-robert (Fig. 6), after the flower has faded, the central axis gradually elongates (Fig. 6, *c*, *d*). The seeds, five in number, are situated at the base of the column, each being inclosed in a capsule, which terminates upward in a rod-like portion, which at first forms part of the central axis, but gradually detaches itself. When the seeds are ripe the ovary raises itself into an upright position (Fig. 6, *e*); the outer layers of the rod-like termination of the seed-capsule come to be in a state of great tension, and eventually detach the rod with a jerk, and thus throw the seed some little distance. Fig. 6, *f*, represents the central rod after the seeds have been thrown. In some species, as for instance in *Geranium dissectum*, Fig. 7, the capsule-rod remains attached to the central column, and the seed only is ejected.

It will, however, be remembered that the capsule is, as already observed, a leaf folded on itself, with the edges inward, and in fact in the geranium the seed-chamber opens on its inner side. You

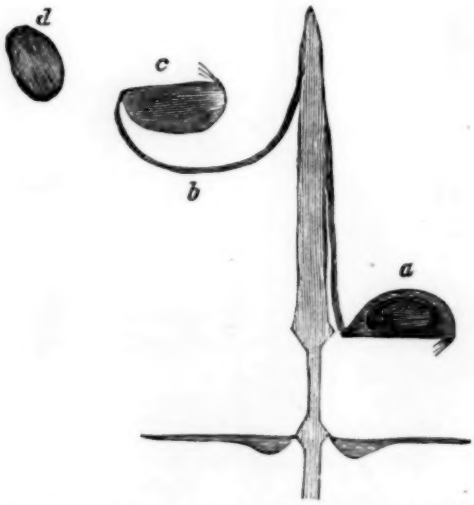

Diagram. FIG. 7.—GERANIUM DISSECTUM. *a*, just before throwing seed; *b*, just after throwing seed; *c*, the capsule still attached to the rod; *d*, the seed.

will, therefore, naturally observe to me that, when the carpel bursts outward, the only effect would be that the seed would be forced against the outer wall of the carpel, and that it would not be ejected, because the opening is not on the outer but on the inner side. Your remark is perfectly just, but the difficulty has been foreseen by our

geraniums, and is overcome by them in different ways. In some species, as for instance in *Geranium dissectum*, a short time before the dehiscence, the seed-chamber places itself at right angles to the pillar (Fig. 7, *a*). The edges then separate, but they are provided with a fringe of hairs, just strong enough to retain the seed in its position, yet sufficiently elastic to allow it to escape when the carpels burst away, remaining attached, however, to the central pillar by their upper ends (Fig. 7, *c*).

In the common herb-robert (Fig. 8), and some other species, the arrangement is somewhat different. In the first place, the whole carpel springs away (Fig. 8, *b* and *c*). The seed-chamber (Fig. 8, *c*) detaches itself from the rod of the carpel (Fig. 8, *b*), and when the seed is flung away remains attached to it. Under these circumstances it is unnecessary for the chamber to raise itself from the central pillar, to which accordingly it remains close until the moment of disruption (Fig. 6, *e*). The seed-chamber is, moreover, held in place by a short tongue which projects a little way over its base; while, on the other hand, the lower end of the rod passes for a short distance between the seed-capsule and the central pillar. The seed-capsule has also near its apex a curious tuft of silky hair (Fig. 8, *c*), the use of which I will not here stop to discuss. As the result of all this complex mechanism, the seeds when ripe are flung to a distance which is surprising when we consider how small the spring is. In their natural habitat it is almost impossible to find the seeds when once thrown. I, therefore, brought some into the house and placed them on my billiard-table. They were thrown from one end completely over the other, in some cases more than twenty feet.

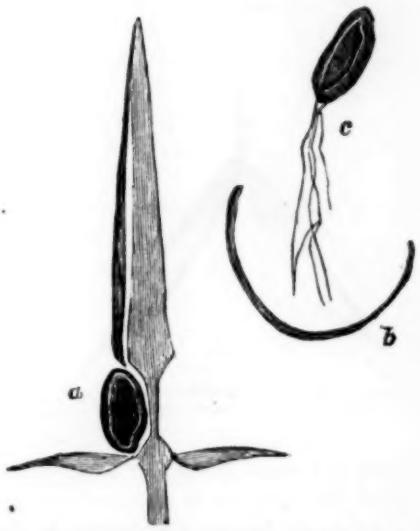

Diagram. FIG. 8.—GERANIUM ROBERTIANUM. *a*, just before throwing the seed; *b*, the rod; *c*, the seed enclosed in the capsule.

Some species of vetch, again, and the common broom, throw their seeds, owing to the elasticity of the pods, which, when ripe, open suddenly with a jerk. Each valve of the pod contains a layer of woody cells, which, however, do not pass straight up the pod, but are more or less inclined to its axis (Fig. 9). Consequently, when the pod bursts it does not, as in the case of *Cardamine*, roll up like a watch-spring, but twists itself more or less like a corkscrew.

I have mentioned these species because they are some of our commonest wild flowers, so that during the summer and autumn we may, in almost any walk, observe for ourselves this innocent artillery. There are, however, many other more or less similar cases. Thus the squirting cucumber (*Momordica elaterium*), a common plant in the south of Europe, and one grown in some places for medicinal purposes, effects the same object by a totally different mechanism. The

FIG. 9.—VICIA SEPIUM. The line *a b* shows the direction of the woody fibres.

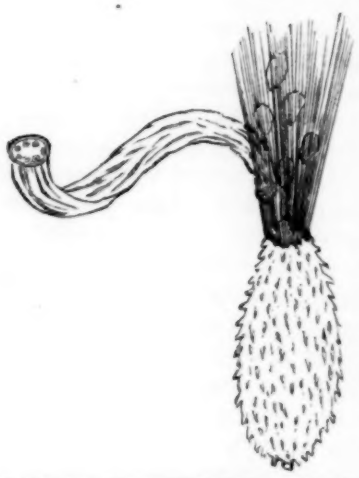

FIG. 10.—THE SQUIRTING CUCUMBER (*Momordica elaterium.*)

fruit is a small cucumber (Fig. 10), and when ripe it becomes so gorged with fluid that it is in a state of great tension. In this condition a very slight touch is sufficient to detach it from the stalk, when the pressure of the walls ejects the contents, throwing the seed some distance. In this case, of course, the contents are ejected at the end by which the cucumber is attached to the stalk. If any one touches one of these ripe fruits, they are often thrown with such force as to strike him in the face. In this the action is said to be due to endosmosis.

In *Cyclanthera*, a plant allied to the cucumber, the fruit is unsymmetrical, one side being round and hairy, the other nearly flat and smooth. The true apex of the fruit, which bears the remains of the flower, is also somewhat eccentric, and, when the seeds are ripe, if it is touched even lightly, the fruit explodes and the seeds are thrown to some distance. The mechanism by which this is effected has been described by Hildebrand. The interior of the fruit is occupied by loose cellular structure. The central column, or placenta, to which the seeds are attached, lies loosely in this tissue. Through the solution of its earlier attachments, when the fruit is ripe, the column adheres only at the apical end, under the withered remains of the flower, and at the swollen side. When the fruit bursts, the placenta unrolls, and

thus hurls the seeds to some distance, being even itself sometimes also torn away from its attachment.

Other cases of projected seeds are afforded by *Hura*, one of the *Euphorbiæ*, *Collomia*, *Oxalis*, some species allied to *Acanthus*, and by *Arceuthobium*, a plant allied to the mistletoe, and parasitic on junipers, which ejects its seeds to a distance of several feet, throwing them thus from one tree to another.

Even those species which do not eject their seeds often have them so placed with reference to the capsule that they only leave it if swung or jerked by a high wind. In the case of trees, even seeds with no special adaptation for dispersion must in this manner be often carried to no little distance; and to a certain, though less extent, this must hold good even with herbaceous plants. It throws light on the (at first sight) curious fact that in so many plants with small, heavy seeds, the capsules open not at the bottom, as one might perhaps have been disposed to expect, but at the top. A good illustration is afforded by the well-known case of the common poppy (Fig. 11), in which the upper part of the capsule presents a series of little doors (Fig. 11, *a*), through which, when the plant is swung by the wind, the seeds come out one by one. The little doors are protected from rain by overhanging eaves, and are even said to shut of themselves in wet weather. The genus *Campanula* is also interesting from this point of view, because some species have the capsules pendent, some upright, and those which are upright open at the top, while those which are pendent do so at the base.

FIG. 11.—SEED-HEAD OF POPPY (*Papaver.*)

In other cases the dispersion is mainly the work of the seed itself. In some of the lower plants, as, for instance, in many sea-weeds, and in some allied fresh-water plants, such as *Vaucheria*, the spores * are covered by vibratile cilia, and actually swim about in the water, like infusoria, till they have found a suitable spot on which to grow. Nay, so much do the spores of some sea-weeds resemble animals, that they are provided with a red "eye-spot" as it has been called, which, at any rate, seems so far to deserve the name that it appears to be sensitive to light. This mode of progression is, however, only suitable to water-plants. One group of small, low-organized plants (*Marchantia*) develop among the spores a number of cells with spirally thickened walls, which, by their contractility, are supposed to disseminate the spores. In the common horse-tails (*Equisetum*), again, the spores are provided with curious filaments, terminating in expansions, and known

* I need hardly observe that, botanically, these are not true seeds, but rather motile buds.

as "elaters." They move with great vigor, and probably serve the same purpose.

In much more numerous cases, seeds are carried by the wind. For this, of course, it is desirable that they should be light. Sometimes this object is attained by the character of the tissues themselves, sometimes by the presence of empty spaces. Thus, in *Valerianella auricula*, the fruit contains three cells, each of which would naturally be expected to contain a seed. One seed only, however, is developed, but, as may be seen from the figure given in Mr. Bentham's excellent "Handbook of the British Flora," the two cells which contain no seed actually become larger than the one which alone might, at first sight, appear to be normally developed. We may be sure from this that they must be of some use, and, from their lightness, they probably enable the wind to carry the seed to a greater distance than would otherwise be the case.

In other instances the plants themselves, or parts of them, are rolled along the ground by the wind. An example of this is afforded, for instance, by a kind of grass (*Spinifex squarrosus*), in which the mass of inflorescence, forming a large round head, is thus driven for miles over the dry sands of Australia until it comes to a damp place, when it expands and soon strikes root.

So, again, the *Anastatica hierochuntica*, or "rose of Jericho," a small annual with rounded pods, which frequents sandy places in Egypt, Syria, and Arabia, when dry, curls itself up into a ball or round cushion, and is thus driven about by the wind until it finds a damp place, when it uncurls, the pods open, and sow the seeds.

These cases, however, in which the seeds are rolled by the wind along the ground are comparatively rare. There are many more in which seeds are wafted through the air. If you examine the fruit of a sycamore you will find that it is provided with a wing-like expansion, in consequence of which, if there is any wind when it falls, it is, though rather heavy, blown to some distance from the parent tree. Several cases are shown in Fig. 12: for instance, the maple, *a*, sycamore, *b*, hornbeam, *d*, elm, *e*, birch, *f*, pine, *g*, fir, *h*, and ash, *i*, while in the lime, *c*, the whole bunch of fruits drops together, and the "bract," as it is called, or leaf of the flower-stalk, serves the same purpose.

In a great many other plants the same result is obtained by flattened and expanded edges. A beautiful example is afforded by the genus *Thysanocarpus*, a North American crucifer; *Th. laciniatus* has a distinctly winged pod; in *T. curvipes* the wings are considerably larger; lastly, in *T. elegans* and *T. radians* the pods are still further developed in the same direction, *T. radians* having the wing very broad, while in *T. elegans* it has become thinner and thinner in places, until at length it shows a series of perforations. Among our common wild plants we find winged fruits in the dock (*Rumex*) and in the common parsnip (*Pastinaca*). But though in these cases the object to be obtained—namely, the dispersion of the seed—is effected in a

similar manner, there are differences which might not at first be suspected. Thus in some cases, as, for instance, the pine, it is the seed itself which is winged; in *Thlaspi arvense* it is the pod; in *Entada*, a leguminous plant, the pod breaks up into segments, each of which is

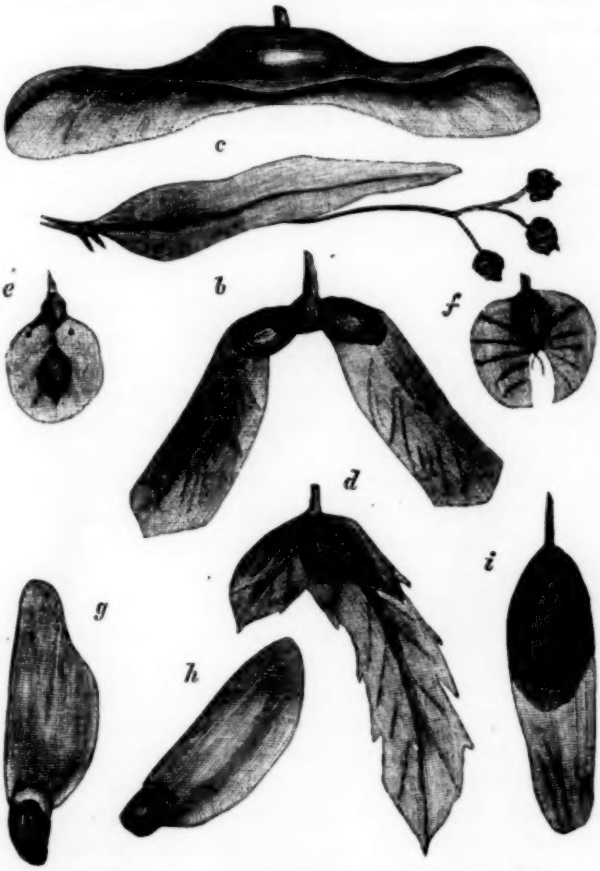

Fig. 12.—*a*, maple; *b*, sycamore; *c*, lime; *d*, hornbeam; *e*, elm; *f*, birch; *g*, pine; *h*, fir; *i*, ash.

winged; in *Nissolia* the extremity of the pod is expanded into a flattened wing; lastly, in the lime, as already mentioned, the fruits drop off in a bunch, and the leaf at the base of the common flower-stalk, or "bract," as it is called, forms the wing.

In *Gouania retinaria* of Rodriguez the same object is effected in another manner; the cellular tissue of the fruit crumbles and breaks away, leaving only the vascular tissue, which thus forms a net inclosing the seed.

Another mode, which is frequently adopted, is the development of long hairs. Sometimes, as in Clematis, Anemone, Dryas, these hairs take the form of a long, feathery awn. In others the hairs form a tuft

or crown, which botanists term a pappus. Of this the dandelion and John Go-to-bed-at-noon, so called from its habit of shutting its flowers about mid-day, are well-known examples. Tufts of hairs, which are themselves sometimes feathered, are developed in a great many Composites, though some, as, for instance, the daisy and lapsana, are without them: in some very interesting species, of which the common *Thrincia hirta* of our lawns and meadows is one, there are two kinds of fruits, as shown in Fig. 13, *b*, one with a pappus and one without. The former are adapted to seek "fresh woods and pastures new," while the latter stay and perpetuate the race at home.

A more or less similar pappus is found among various English plants—in the Epilobium (Fig. 13, *a*), Thrincia (Fig. 13, *b*), Tamarix

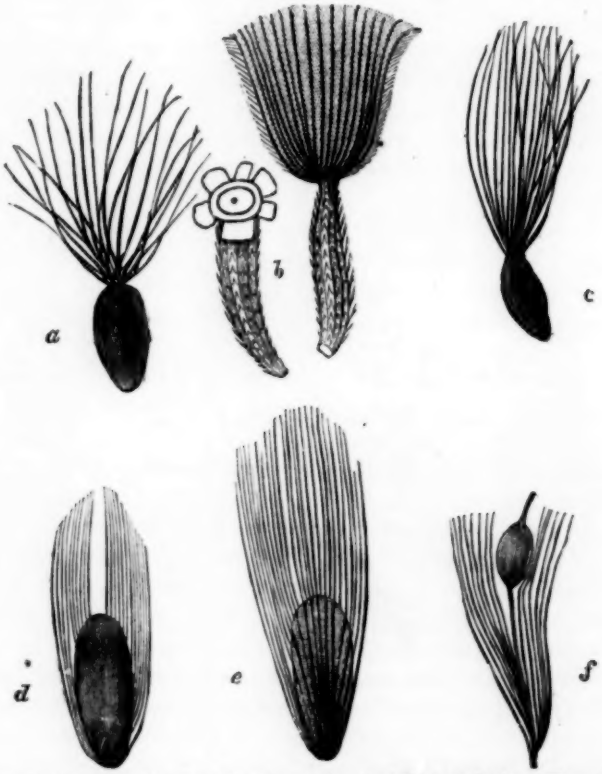

FIG. 13.—*a*, willow herb (*Epilobium*); *b*, two forms of seed of *Thrincia hirta*; *c*, Tamarix; *d*, willow (*Salix*); *e*, cotton grass (*Eriophorum*); *f*, bulrush (*Typha*).

(Fig. 13, *c*), willow (Fig. 13, *d*), cotton-grass (Fig. 13, *e*), and bulrush (Fig. 13, *f*); while in exotic species there are many other cases—as, for instance, the beautiful oleander. As in the wings, so also in that of the pappus, it is by no means always the same part of the plant which develops into the crown of hairs. Thus in the Valerians and Com-

posites it is the calyx; in the bulrush the perianth; in Epilobium the crown of the seed; in the cotton-grass it is supposed to represent the perianth; while in some, as, for instance, in the cotton-plant, the whole outer surface of the seed is clothed with long hairs. Sometimes, on the contrary, the hairs are very much reduced in number, as, for instance, in some species of *Æschynanthus*, where there are only three, one on one side and two on the other. In this case, moreover, the hairs are very flexible, and wrap round the wool of any animal with which they may come in contact, so that they form a double means of dispersion.

In other cases seeds are wafted by water. Of this the cocoanut is one of the most striking examples. The seeds retain their vitality for a considerable time, and the loose texture of the husk protects them and makes them float. Every one knows that the cocoanut is one of the first plants to make its appearance on coral islands, and it is, I believe, the only palm which is common to both hemispheres.

The seeds of the common duckweeds (*Lemna*) sink to the bottom of the water in autumn, and remain there throughout the winter; but in the spring they rise up to the surface again, and begin to grow.—*Fortnightly Review.*

[*To be continued.*]

SUNSTROKE AND SOME OF ITS SEQUELÆ.

By Sir JOSEPH FAYRER, M. D., F. R. S.

UNDER the designations of sunstroke, *coup-de-soleil*, heat-apoplexy, heat-asphyxia, thermic fever, ardent fever, insolation, and others, are included certain pathological states which, though differing from each other materially, are not unfrequently confounded.

1. There is simple syncope from exhaustion caused by heat.

2. A condition analogous to shock, due to the action of the direct rays of a powerful sun on the brain and cord; the nerve-centers, especially the respiratory, are affected; respiration and circulation rapidly fail, and death may result; recovery is frequent, though not always perfect.

3. Overheating of the whole body, blood, and nerve-centers, either from direct exposure to the sun's rays, or, more frequently, to a high temperature out of them; causing vaso-motor paralysis and intense pyrexia (fever); respiration and circulation fail, and asphyxia follows. Recovery frequently occurs, but is often incomplete, owing to structural changes in the centers, giving origin to a variety of symptoms indicative of lesions of a grave character.

The cases of simple exhaustion and syncope may occur during

great fatigue or over-exertion, or when there is depression of vital power from any cause during exposure to a high temperature. There is depression of nerve-force and of muscular power; the skin is pale, cold, and moist, the pulse feeble. Death may occur in this state from failure of the heart; but complete recovery more frequently occurs. Asphyxia and apnœa (stoppage of the breath) may come on after premonitory symptoms of depression and weakness, during exposure of the head and spine to the direct rays of a powerful sun, when the atmosphere is much heated, and the nervous energy is depressed by over-fatigue, illness, or dissipation. The brain and respiratory nerve-centers are overwhelmed by the sudden rise of their temperature, and respiration and circulation fail.

Recovery, though frequently complete, is sometimes tedious and occasionally imperfect, ending in serious impairment of health or intellect.

The symptoms of this form of sunstroke are those of sudden and violent derangement of the nerve-centers, unconsciousness, cold shivers, feeble pulse; all the signs of depression, terminating in death by shock; or fatal reaction may result with a variety of conditions pointing to injury to the cerebro-spinal system. In another class of cases there is ardent fever, the body generally, including the nerve-centers, is heated intensely; this may occur quite independently of the direct action of the sun's rays. It comes on frequently at night, or in the shade, in a building or tent, especially in persons who are depressed by fatigue, bad air, overfeeding, alcoholic stimulants and the consequent depression, want of rest, illness, and notably when the air is impure from overcrowding, or from insufficiency of cubic space.

The temperature of the body may rise to 108°–110°; respiration and circulation fail; there are hurried, gasping respiration, great restlessness; pungently hot skin, sometimes dry, occasionally moist. The pulse varies; in some it is full and laboring, in others quick and jerking; the head, face, and neck are livid and congested; the carotid pulsation is very perceptible; the pupils, at first contracted, dilate widely before death. Coma, stertor, delirium, convulsions frequently epileptiform in character, with relaxation of sphincter, and suppression of urine—these are the precursors of death by asphyxia, and it may be that there is cerebral hæmorrhage.

Such are the cases to which the term heat-apoplexy is given; and a large proportion of the fatal attacks among Europeans in India are so caused. Recovery may partially occur, to be followed by relapse and death, or secondary consequences, the result of tissue-change, may destroy life or impair health and intellect at a later period. The premonitory symptoms of this form of the disease may appear some hours or even days before the dangerous condition just described supervenes. There may be general *malaise*, disordered secretions, profuse and frequent micturition, restlessness, insomnia (sleeplessness), apprehension

of impending evil, hurried and shallow breathing, disturbance about the heart, gasping, giddiness, headache, occasionally nausea or vomiting, thirst, anorexia (want of appetite), feverishness, which soon amounts to fervent heat of skin; the surface may be dry or moist, the pulse varies; and these conditions gradually become aggravated and frequently are worse at night, when the patient passes into a state of unconsciousness and dies.

The symptoms point to a profoundly disturbed state of the cerebro-spinal nerve-centers, and to pathological changes in the organs whose functions have been so greatly disturbed.

Death is caused by asphyxia and apnœa, and in some cases probably by cerebral hæmorrhage. Recovery is often incomplete, resulting in permanent impairment of health, and generally in intolerance of heat and of exposure to the sun. These morbid conditions being due to heat alone, are liable to occur whenever there is exposure to a high temperature, whether solar or artificial. Soldiers marching or fighting, when oppressed by weight of clothing or accoutrements, are apt to suffer either from simple heat-exhaustion or from that form of insolation which results from direct action of a powerful sun on the head and spine. Soldiers, laborers, artificers, and people in factories, heated rooms, hospitals, barracks, tents, and even ships, may suffer from heat-exhaustion, which may pass into the same dangerous condition of heat-asphyxia. People in the hay-field, or otherwise exposed to great heat, especially if they have indulged in excess of alcoholic stimulants and food, may suffer. Weak persons with defective hearts may die in this state of syncope. Soldiers or others, when exposed to great heat, may drop out of the ranks, fall in a state of syncope and die on the spot, or pass into a state of coma and die later; or they may recover, after being in great danger, with damaged nerve-centers, and are rendered quite unfit for further service, or even residence in a hot climate. These cases occur on exposure to the direct action of the sun's rays when the atmospheric temperature is also high, and especially when unusual exertion is made, or when the individual is depressed by previous illness or the exhaustion due to dissipation, intemperance, or even undue indulgence in stimulants.

But the most serious cases are those that come on under cover by night as well as by day, and apart from the direct solar rays. Heat alone, especially when the atmosphere is loaded with moisture so as to prevent evaporation from the person, is the real cause of the disease.

Vigorous, healthy persons of moderately spare frame, with sound viscera, and who are of temperate habits, if the atmosphere be pure and moderately dry, can sustain a great amount of heat. Acclimatization has also some influence in conferring toleration. Fresh arrivals in the tropics are more prone to suffer than those who have become accustomed to the climate, and have learned how to protect themselves. It is well known that a native can bear an amount of sun on

his bare head and naked body with indifference, almost pleasure, that would rapidly prostrate a European. But when the temperature rises above a certain standard all succumb, and natives of India suffer and die like others in numbers every year from *loo marna* (hot-wind stroke).

The extent and duration of the toleration of heat depend much on the vigor of constitution and actual state of health. The refrigerating powers of the body, when in health, enable it to support a very high temperature, considerably above that of the blood. Thus, in the hot winds little inconvenience is felt so long as perspiration is free, but, when that fails, suffering soon ensues, and the danger is great.

In the fourteenth annual report of the Sanitary Commissioner with the Government of India, 1877, it is stated that two hundred and thirty-five cases of heat-apoplexy and sunstroke occurred in the army in India, of which seventy were fatal. Of those who recover, or rather do not die, many are permanently injured, and remain invalids for the rest of life, which is frequently shortened by the changes induced.

No remarkable morbid change is observed in cases where death has occurred suddenly. The heart may be firmly contracted, and the lungs and brain and its membranes congested, but not invariably, for sometimes the reverse conditions exist; and the blood is dark and clotted, its coagulability is impaired, and it is deficient in oxygen. In death from ordinary cases of thermic fever or insolation, the pulmonary system is often deeply congested; the heart is firmly contracted with coagulation of myosin; the venous system is engorged; the body may be marked with livid patches; the blood shows a tendency to a separation of its fluid and solid constituents, and may be acid in reaction; and the body retains a high temperature for some time after death. The brain and membranes may be congested, but the disease is essentially asphyxia, not apoplexy.

In cases of simple exhaustion, remove the person to a cooler place, if possible. Give a douche, but not too prolonged, or it may overdepress. A stimulant may be useful; rouse, and gently stimulate; remove tight and oppressive clothing. Treat as in ordinary fainting—apply ammonia to nostrils, etc. Let the patient rest, and avoid exposure to over-fatigue or to great heat. In the form of sunstroke where the person is struck down suddenly by a hot sun, remove him into the shade, and allow a douche of cold water to fall from a height on his head and body. This should be freely resorted to, the object being twofold—to reduce the temperature of the over-heated centers, and to rouse by reflex action. During the assault on the "White-House picket," at the capture of Rangoon in 1853, numbers of men were struck down by the fierce April sun. They were brought to me, and laid out in rows, perfectly unconscious, *in their red coats and black leather stocks*. They nearly all recovered—for the time, at all events—under the influence of the douche, freely applied over the head and

body. In some cases rousing by flagellation with the sweeper's broom was added with great effect, especially in the case of Brigadier-General W——, who I thought must have died. All, or nearly all, recovered, except two, both of whom had been bled on the spot before I saw them.

In addition to the douche, stimulants, such as mustard-plasters, to various parts of the body, legs, abdomen, etc., and stimulating injections, which relieve the loaded bowels and at the same time rouse, may be useful.

When I say such cases recovered, I refer to the reaction at the time. In some there were consecutive symptoms of fever, headache, etc.; and, were we able to trace their subsequent history, we should probably find that complete recovery never occurred. If recovery is incomplete, and followed by indications of disordered nerve-centers or of meningitis, other treatment of a more active character will be needed, according to the conditions.

Future exposure to the sun should be carefully guarded against, and, unless recovery has been rapid and complete, the sufferer, if in India or the tropics, should be removed to a cooler climate, where he should be protected from all excitement of mind or body, and the greatest care be taken not only to avoid all errors or excesses of diet, but also of stimulants.

In the graver cases of thermic fever, or heat-asphyxia, heat being the primary cause of the disease, the object is to reduce temperature as speedily as possible and before tissue-changes have been caused. Remedies adapted to fevers may be used sometimes with advantage. Bleeding has now happily been abandoned except in rare and peculiar cases. The treatment, generally, consists in the judicious application of cold by affusion, or by ice, taking care not to reduce temperature too low. Great care should be taken not to prolong the cold application too far, as danger would attend continued depression of the temperature below the normal standard of blood-heat. The bowels should be relieved, and blisters may be applied to the scalp and neck, though I can not but say I have not much faith in their efficacy. In the epileptiform convulsions that so frequently occur, the inhalation of chloroform may be useful, but its administration must be carefully watched. The earliest and most severe symptoms having subsided, the febrile condition that follows is to be treated on ordinary principles; the diet must be carefully regulated. As improvement progresses, symptoms of intra-cranial mischief may begin to supervene; where the indications are of meningitis, iodide of potash and counter-irritation may be of service; removal to a cooler climate is essential.

The sequelæ of sunstroke are often very distressing, and render the patient a source of anxiety and suffering to himself and to his friends.

Among them are, in various degrees of intensity, irritability, im-

paired memory, epilepsy or epileptiform attacks, headache, mania, partial or complete paraplegia (paralysis of the lower half of the body), partial or complete blindness, extreme intolerance of heat, especially of the sun's rays, rendering a person otherwise fairly healthy quite incapable of living in hot climates or of enduring any exposure to the sun; or, the attack may gradually end in complete fatuity, dementia, or epilepsy, perchance both; chronic meningitis, with thickening of the calvarium, accounting for the intense pains in the head; or, in a lesser degree, in disordered nervous condition and general functional derangement.

The less severe symptoms—those probably of the slighter forms of meningitis, or of cerebral change—occasionally pass away after protracted residence in a cold climate; they are, however, not unfrequently the cause of suffering, and of danger to and shortening of life, pointing to permanently disturbed if not structurally altered cerebro-spinal centers.—*Abridged from Brain.*

THE VALUE OF OUR FORESTS.

By N. H. EGLESTON.

IT may be considered as now established, by the most careful and intelligent investigation of the subject, that the highest welfare of almost any country demands that from one fifth to one fourth of its surface shall be covered with trees, and that these shall be, to a good degree, in masses. England will at once be adduced, perhaps, as a country not well wooded, and yet one which compares favorably with others in regard to the conditions of living and her competency to secure the welfare of all classes of her people. But England is specially favored in other respects. She has a moist and equable climate secured to her by her surrounding seas and high latitude, while the general shape of her surface and her geological constitution exempt her from the alternations of flood and drought which in so many other countries result from the absence of forests.

Whether the forests insure a greater rainfall in their vicinity than is received upon an equal area of open land has been disputed among scientific men, though the preponderance of opinion now seems to favor the conclusion that the rainfall is most abundant in wooded regions. This corresponds also with the prevalent belief of the common people, the unscientific but practical observers.

A special committee of the Royal Academy of Vienna, reporting in 1874 upon a "Memoir of Mr. Hofrath Wex upon the Diminution of the Water of Rivers and Streams," used the following language upon this particular point: "The question of the influence of forests upon

the amount of precipitation has for some time engaged the attention of naturalists. Such an influence has been asserted, partly from theoretic considerations and partly on account of the entire change presented by the climatic relations of the countries in which the forests have disappeared. . . . It is probable that such influence exists; but while on the one hand its consequences may be over-estimated, on the other hand there is want of direct proof, inasmuch as the rain measurements have been continued for too short a time, both at stations situated within the woods and outside of them in the open fields. . . .

"The commission consequently concluded that an influence of the woods upon the amount of rain deposited, and especially upon the yearly contribution, is probable, although direct observation does not give sufficient evidence to determine its extent, or positively its existence."

Dr. Rogers, of Mauritius, gives this testimony: "So late as 1864 the island was resorted to by invalids from India, as the 'pearl' of the Indian Ocean—it being then one mass of verdure. But, when the forests were cleared to gain space for sugar-cultivation, the rainfall diminished, the rivers dwindled down to muddy streams, the water became stagnant in cracks, crevices, and natural hollows, while the equable temperature of the island entirely changed, drought was experienced in the midst of the ocean, and thunder-showers were rarely any longer witnessed. . . . The hills were subsequently planted with trees, and the rivers and streams resumed their former dimensions."

The Island of Ascension was formerly almost a barren rock. The supply of water was very scanty, derived solely from a few springs, and water was often brought from the Cape of Good Hope, and even from England, for the needs of the garrison. About twenty-five years ago the planting of trees and shrubs and the cultivation of the soil were undertaken vigorously. The water-supply has increased with the progress of this work, until now it is excellent, and the garrison and ships visiting the island are supplied with abundance of water and vegetables of various kinds.

Observations in France by M. Fautrat, reported to the Academy of Sciences, showed that, in a dense wood of five hundred hectares, a rain-gauge fixed on a tall poplar received much more water than one of similar height three hundred metres beyond the borders of the woods. Experiments continued during two years confirmed the first results, and an instrument placed over a forest of *Pinus sylvestris*, at twelve metres' elevation, received ten per cent. more water than one at the same height in the open fields.

But, however the case may be as to the effect of forests upon the amount of rainfall, there can be no doubt that they secure a more equable distribution of the rains than is usual in the open country. They are also great storehouses of moisture. By their myriad leaves they intercept the moisture of the passing clouds or the damp winds, and convey it to the ground, or hold it within their embrace ready to

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be given out again to a drier atmosphere and to surrounding objects. It is well known, also, that the leaves of the trees, as they fall from year to year and decay, form a spongy soil, which absorbs the rains that fall upon it, and retains them, when otherwise, where there is any declivity, the water would run off almost immediately. The roots of the trees, likewise, penetrating deeply into the ground, conduct a considerable portion of the moisture falling from the clouds far below the spongy surface-soil. Shaded by the leaves and branches of the trees, the moisture thus stored up is not soon evaporated, as it would be from the open ground, but passes off slowly into the surrounding air, and imparts its benefits in the largest measure to the adjacent lands.

While thus sending out their moisture upon the cultivated fields around them, and thereby favoring the growing crops, the forests aid the work of husbandry in another way. By their very mass they serve as a mechanical barrier against the winds, which are often so injurious to crops. Every one who has visited the forest with any frequency knows that he is obliged to go but a short distance within its borders to escape the influence of even a violent wind. So it is also well known that the woodmen engaged in felling trees in the forest, which they usually do in the winter, find no inconvenience from cold winds, as these penetrate the wood but a short distance, even when the trees are stripped of their leaves. And as the woods shelter those within them from the winds, so do they protect the adjacent fields from the blasts which would otherwise sweep over them, and, by their cold, their mechanical force, and their desiccating influence, prove very injurious to crops. The presence of a forest is often, on this account, in its effect upon adjacent lands, equivalent to a change of latitude of several degrees. This is sufficient to make the cultivation of certain crops successful which otherwise could not be undertaken. There are districts of France and Italy where the olive and the orange once flourished, but where now, on account of the change of climate resulting from the extensive removal of the forests which formerly abounded, they can no longer be grown with success. It is not going too far to say that, if one fourth of the land now under cultivation were converted into forests and groves so disposed as to form barriers against the coldest and strongest or most prevalent winds, the remaining three fourths would have more value for agricultural purposes than the whole has at present. This would result from the greater variety of crops which could be raised, their earlier maturity, the greater certainty of growth, and the larger aggregate yield, while there would be, in addition, the large product of the forest itself, to be used, as occasion might demand, for fuel and lumber.

The effect of trees in preventing or diminishing the evaporation from the ground caused by the passage of drying winds is far from being properly appreciated. We often speak of the effect of wind in

drying muddy roads as being greater than that of sunshine, while we fail to recognize the fact that the desiccating effect is the same upon the fields as upon the roads.

Forests have a very obvious influence also in preventing the occurrence of floods and droughts. When the rains fall upon the open, unwooded country, unless it is of a quite level character, they flow off at once into the beds of the neighboring streams, and pour their united flood into the larger rivers, swelling their volume rapidly to such an extent that their waters can not be confined within their banks, but break out and overspread the adjacent lands, carrying destruction oftentimes to the growing crops, covering fertile fields with masses of gravel and rubbish of various sorts, interfering with manufacturing interests, and often destroying life itself. These floods are succeeded by periods of drought. The flow of water in the streams shrinks away, often leaving their beds almost dry. As a consequence, crops and herds suffer, the mill-wheels are stopped or turn but slowly and feebly, the transportation of merchandise is impeded, and the various industries of life suffer. The forests prevent such a deplorable condition of things. The spongy soil formed by their fallen leaves, accumulated for years, retains the rain which falls upon it as in a great reservoir, and obliges it to flow off gradually instead of with a sudden flood. The difference in the operation in the two cases may be likened to that between the flow of the rain from a smoothly shingled house-roof and from one covered with thatch. In the one case the water runs at once to the ground without any impediment. In the other it sinks into the straw to a considerable depth and trickles thence for days perhaps after the rain has ceased to fall. So, our hillsides and mountain-slopes, where the forests are most usually found, are the world's great roofs or water-sheds, from which, if they are thatched with trees, the water flows off slowly and in the most desirable manner into the streams and upon the lands of the regions below, but, if stripped of this protecting covering, then with sudden and disastrous flood which no art of man can withstand.

This is well illustrated by the report of the effect of a storm in two neighboring ravines in the valley of the Durance in southeastern France, the Ravine de St. Phalez and the Ravine de la Combe d'Yeuse. St. Phalez runs north and south, has a basin of reception fifty hectares (one hundred and twenty-five acres) in extent, is well cultivated and has an argillaceous soil. Combe d'Yeuse is much more steep, has a basin of reception of two hundred and fifty hectares (seven hundred and twenty-five acres), and is covered with pines and oaks. In other respects the two ravines are alike.

In September, 1864, an abundant rainfall took place. On the morning after the rain the ravine of St. Phalez was flowing with a small stream. The Combe d'Yeuse was dry. During the day a water-spout struck the mountain and prevailed for not more than forty min-

utes; hardly had it begun when the torrent of St. Phalez became awful; it filled the ravine from bank to bank, seizing and carrying off rocks which had been used to form a road, which was considered safe against all contingencies. At the same time, that of Combe d'Yeuse and all those traversing wooded lands remained dry or carried a comparatively insignificant quantity of water.

The forest conservator describes a second scene on the same spot in the following October. In a few minutes after the rain began, the torrent of St. Phalez gushed forth with the same destructive effect as before. But after an entire day of rain a small stream appeared coming down the Ravine d'Yeuse, which increased for three days and then for two declined. The only damage done was to a little footpath. "Thus we have," says the reporter, "two torrents very near to each other, and exposed to the same conditions, except that the basin drained by the one comprises fifty hectares of cultivated lands, that of the other two hundred and fifty hectares of woodlands. The first receives and allows to flow away the waters of the greater part of a storm in a few hours at most, causing thereby considerable damage; the second, which has received a greater quantity of rain, stores it—keeps it for two days—evidently retaining a portion of it, and takes three or four days to yield up the surplus, which it does in the form of a limpid and inoffensive stream."

So also in the colder latitudes, where during the wintry months the moisture of the atmosphere is precipitated in the form of snow and accumulates often to a great depth, the conservative influence of the forest is very obvious. The temperature of the woods is warmer in winter, as it is cooler in summer, than that of the open ground. Sheltered from the winds and, to a considerable degree, from the cold, the snows themselves forming a protecting covering, the earth seldom freezes in the forest, and the warmth from the ground below gradually melts the snow and so feeds the springs and streams as to maintain in them an equable flow. As the warmer sun and wind of advancing spring-time begin to heat the surface of the ground, the screen of the trees prevents their influence from being so sensibly felt in the woods as in the open fields. The result is, that the snows dissolve gradually, and the resultant water, sinking in the first place and for the most part into the spongy, leafy soil, flows away gently, as do the rains of summer-time, into the valleys and fields below. But, when the forests have been removed, the case is very different. The snows, no longer screened from the sun's rays and the warm winds by the interposed foliage or even the naked trunks of the trees, are rapidly dissolved, often before the earth beneath or the ground over which the waters must flow has been unlocked from the wintry frosts. As a necessary result, thousands of rivulets are formed almost at once, which are precipitated into the adjacent streams, whose rapidly increased volumes are hurried to the larger streams below, and thus we

have our spring floods, often so destructive to property as well as life.

There is another aspect in which the forests are to be regarded, but in which we have hardly begun to consider them properly, and that is the economical one, as the continuous producers of fuel, and of lumber for use in the mechanic arts. With our boundless area of cheap lands, covered originally with forests to such an extent that the trees have been regarded as an obstruction to agriculture, and so to be swept away often by fire rather than to await the slower process of the axe, we have thought little of the forest as anything of permanent value. Added to this the practically unlimited area of our coal-fields has served to prevent any apprehension of loss from the destruction of the forests. That there is ever to come a time when we may suffer from a scarcity of wood for fuel or for the arts, hardly seems to have entered many minds.

Very different is the settled feeling in other countries in respect to the value of the forests. When in some portions of Europe the peasant has to travel miles on foot to bring home, as the result of a whole day's labor, an armful of wood to burn, and can afford to bake bread but once in six months because fuel is so scarce and dear; and when England, with only four or five per cent. of woodland, is gravely and anxiously figuring out the time when her coal-fields will be exhausted, and her vast manufacturing interest will be at the expense of purchasing its fuel from other countries or suffer inevitable decline or extinction—the importance of the forest, in an economical as well as in a political point of view, becomes at once apparent. The coal-fields are not growing, and never can be made to grow again. They were deposited ages since, once for all, and, so far as we can see, are to have no successors or substitutes but the living trees, following each other from generation to generation.

It is not to be wondered at, therefore, that the European nations, having learned its value by its loss in greater or less measure, see the forest to be an important factor in all that constitutes national life and comfort, and have given it a place in their thoughts and in their practical arrangements which we have not in ours. It is not surprising that they should establish schools for the special purpose of teaching all that relates to the growth and preservation of the forest, that they should make it a matter of national and political concern, and that the literature of the subject should be so extensive that it is estimated that from the German press alone as many as a hundred volumes and pamphlets on forestry, in some of its aspects, are issued annually.

Germany has given much attention to her forests ever since the days of Charlemagne, who is said to have afforested the Ardennes and established the forest of Osnabrück. The sovereigns of Germany have treated the woodlands not merely as preserves for game and

places for royal enjoyment in its pursuit, but have encouraged their cultivation for the production of fuel and timber, as well as for their value in other respects. It will indicate the careful attention given to the forests in Germany, when we find it officially reported that the net returns of the forests are from two to twelve thalers per hectare (two and a half acres), and the value of the land together with its crop is estimated at fifty-two and a half thalers per hectare.

England, now having a smaller percentage of forest than any country of Europe, with the exception of Spain and Portugal, was well wooded at the remotest historical period; but as early as the thirteenth century, in the time of Henry III, she found it necessary to import pine-lumber, and apprehension began to be felt of the failure of the forests.

Hardly anything has been done in England compared with what has been done in Germany, France, and other Continental countries, to establish and protect the forests. Individuals have done something, as for instance the Duke of Athol, who, in the early part of the present century, planted several thousand acres of the barren hillsides of Scotland with the larch. His successors in the dukedom have followed his worthy example and extended the woodland area, and demonstrated that the work of forestry, rightly prosecuted, is pecuniarily profitable as well as desirable in other respects. It is only within the last few years that the English Government has shown any considerable interest in this subject. Some action has been taken for the purpose of protecting the forests in her colonies from destruction, and quite recently a few thousand acres in England itself have been planted with oaks for the purpose of meeting the future demands of the navy.

The subject of the preservation of the woods is one of the highest practical importance. Man has often acted very unwisely in the exercise of his lordship of the forest, and has suffered greatly, and continues to suffer, in consequence. Great districts once populous, and powerful as populous, have been almost converted into deserts, some of them quite into deserts, and their people diminished in numbers and in power, as the result of a wanton destruction of their forests. France and other European countries have been swept by disastrous floods, or rent by torrents rushing down their mountain-slopes, and carrying masses of rock and gravel into the valleys and plains below, because the forests which would have held the floods in check have been recklessly consumed; and now forest schools are established, and all the power and wealth of governments are put forth for the purpose of staying these evil effects, if possible, by replanting the mountain-sides with trees, and thus restoring the protection which Nature had originally provided. Climates have been changed for the worse, the agricultural productiveness of countries has been lessened, provinces have been depopulated, the health and happiness of nations have been diminished, by the destruction of the forests; and now sci-

ence and art and governmental authority are invoked to unite their powers for the purpose of remedying the evil results.

We are treading the same course that other nations have trod. Says Humboldt, "Men, in all climates, seem to bring upon future generations two calamities at once—a want of fuel and a scarcity of water." With our comparatively sparse population and our continental stretch of forest, it has hardly entered our minds that we could be improvident in the use of our woodlands. It has seemed to us that we had enough, and that for ever; and so we have consumed the forests with a recklessness which has perhaps never been surpassed. We have even sacrificed them by carelessness, or in the wantonness of a temporary greed, utterly regardless of the future. Forests which have been the growth of centuries have been swept off in a day. The lumberman cuts the few noblest trees, or takes only the choicest portions of them for the purposes of the arts, and burns the rest to ashes, thereby precluding another growth upon the spot. The miner does the same, cutting off the already sparse forests, and taking no pains to replace them. And so it is happening that our forest area, particularly in the more recently settled portions of the country, is rapidly diminishing. The opening of the great agricultural regions of the Ohio and the Mississippi Valleys, with their superior attractiveness, has lessened the value of much of the Eastern lands for the purpose of tillage, and, in some portions of New England particularly, what were once corn-fields and pastures, have been abandoned by the cultivator and a growth of trees has come in. But as a whole our forest area has been diminishing for a long time, and never more rapidly than within the last decade. Serious evils have already come from this wasting of the woods, but they have been spread over so wide a stretch of territory that attention has not been called to them in a way to arouse general attention or lead to their remedy. Our streams have a diminished flow of water, while they are marked by alternations of floods and droughts, much greater than formerly prevailed. They are not navigable for so long distances, nor for so large a class of boats, as they once were, nor do they furnish so large or so uniform a supply for the mill-wheels as they did in earlier times. Changes of climate have also resulted, affecting the health of the people and the productiveness of the fields. These effects have been noticed in a multitude of cases. But, in most instances, they have been regarded as isolated and local occurrences, and have not been attributed to their true cause.

In some of our Western States which are almost treeless, the beneficial influence of forests has been forced upon the attention of the people. It has been found that life may not be worth living, though on the richest soil, if that be all. A writer of acknowledged authority, in a lecture before the Illinois Industrial University, speaking of the importance of trees as a shelter of crops from injurious winds, says, "I think it may be safely estimated that an average of one twelfth part of

all our crops of grain and large fruits is destroyed by violent winds, which such a system of protection, or its equivalent in groves, would so far check as to prevent the destruction." Another, whose words are quoted in the "Iowa Horticultural Report" for 1875, speaking of the wintry storms of the Northwest, sometimes known as "blizzards," says, "More people have been frozen within the last year in northwest Iowa and west Minnesota than were ever murdered by the Indians in those counties since their settlement." And he says, in regard to a remedy: "I see none that would do but timber-planting. It alone would stop these terrible winds, modify the climate, and furnish landmarks for the traveler." So Professor Lacy, of the State University, in an address to the Minnesota State Forestry Association, says: "The Minnesota State Forestry Association was organized to meet and deal with the stern realities of facts. It was organized to meet the fact that over more than one third of the great State of Minnesota the winds rush with a howling fury and with a bitter cold that neither beast nor fruit-tree can resist or withstand, and for miles not a single forest-tree rears its head in protest. It was organized to meet the fact that, in a climate which affords six months of winter, much of it fearfully severe, there are thousands of farms on which there does not grow one particle of fuel, and on which it can not be obtained without the expenditure of both money and labor by a people often destitute of means. It was organized to meet the fact that for miles and miles there is not a single landmark to guide the benumbed and benighted traveler. It was organized to meet the fact that to induce human beings to make their houses on such farms is downright inhumanity. . . . The force of the winds on our Western prairies can not be conceived of by you who have always lived within the area of forests. They are simply terrible to endure and appalling to contemplate. They carry death alike to the unprotected beast and the more tender forms of arboreal life."

It is not surprising that people living amid such exposures of life and property, and seeing so manifestly as they do that these are attributable to the absence of trees, should bestir themselves in seeking the appropriate remedy, that they should organize, as they have done, forestry associations, appoint arbor-days, and engage the aid of the State itself in offering bounties for tree-planting, and in exempting forest plantations for a time from taxation. The latter has been done in several of the Western States, and already the work of tree-planting has wrought a perceptible change on many a farm, as to appearance, comfort of living, and productiveness. But the work that is needed is a great one, a work not to be accomplished by planting in a few States or portions of States lines of quick-growing, soft-wooded trees, which may make tolerable wind-breaks in five or six years. This is hardly more than a makeshift at the best. The work is broader and more comprehensive than that, and one which for its due accomplishment needs an intelligent comprehension of the facts

involved in the case, and their far-reaching relations. It is a matter not of present or local exigency merely, but of general and abiding importance. The future of the whole country is involved in it.

Champollion is reported as saying in reference to the great desert of Northern Africa: "And so the astonishing truth dawns upon us that this desert may once have been a region of groves and fountains, and the abode of happy millions. Is there any crime against Nature which draws down a more terrible curse than that of stripping Mother Earth of her sylvan covering? The hand of man has produced this desert, and, I verily believe, every other desert upon the surface of this earth. Earth was Eden once, and our misery is the punishment of our sins against the world of plants. The burning sun of the desert is the angel with the flaming sword who stands between us and paradise."

An awakening of general interest on this subject is needed. To this end the most important step is to get before the people as widely as possible the facts showing the importance of the forests in their relations to climate, to water-supply, to floods and droughts, to commerce and manufactures, to agriculture and to health; the rapidity with which we are destroying our forests and bringing upon ourselves the natural and inevitable results of that course. The history of other nations, as related to their treatment of the forests, should be made widely known, and the danger that this land, or portions of it, by the reckless destruction of its forests, may be converted into a desert, as other lands have been. Thus may we hope to arouse a general interest in the trees, and a disposition to cherish them as our best friends. Meanwhile, let tree-planting be encouraged. Let it be shown, as it has been again and again, that much of our poor and what is commonly regarded as waste land can be made to yield a handsome profit by being devoted to the growth of trees; and that our rough hills and mountain-sides can thus be made of direct pecuniary value, while at the same time they are rendered objects of beauty and the means of protecting our springs, maintaining the flow of our streams, and promoting health and prosperity. With this awakened interest in the forests, sylviculture will come to be one of our arts. We want an intelligent and scientific observation of the facts in regard to trees as related to our various soils and situations. The adaptation of trees to one climate or another, their comparative value for one purpose or another, the obstacles to successful planting—these, and many other things, need to be known as they are not yet known. Some things we can learn from the experiments which have been made and the knowledge which has been gained in Europe. But so different are the trees there and here, and so different the conditions of soil and climate, that the problem set before us is virtually a new one, which must be worked out carefully and patiently on our own ground. The most important advance in this direction yet made here, so far as we know,

has been by the Bussey Institute, in connection with the Arnold Arboretum, at Brookline, Massachusetts. Under the able and judicious management of Professor Sargent, it has already fine plantations of forest-trees, has diffused much valuable information in regard to the growth and importance of trees, and has secured the planting of a large number in various parts of the country. On the foundation of such institutions will naturally be built up in due time schools of instruction in forestry like those of Europe, which will have a recognized and permanent place among us. The European schools of forestry will form the subject of another article.

PRODUCTION OF SOUND BY RADIANT ENERGY.*

By ALEXANDER GRAHAM BELL.

IN a paper read before the American Association for the Advancement of Science, last August, I described certain experiments made by Mr. Sumner Tainter and myself which had resulted in the construction of a "*Photophone*," or apparatus for the production of sound by light;† and it will be my object to-day to describe the progress we have made in the investigation of photophonic phenomena since the date of this communication.

In my Boston paper the discovery was announced that thin disks of very many different substances *emitted sounds* when exposed to the action of a rapidly-interrupted beam of sunlight. The great variety of material used in these experiments led me to believe that sonorousness under such circumstances would be found to be a general property of all matter.

At that time we had failed to obtain audible effects from masses of the various substances which became sonorous in the condition of thin diaphragms, but this failure was explained upon the supposition that the molecular disturbance produced by the light was chiefly a surface action, and that under the circumstances of the experiments the vibration had to be transmitted through the mass of the substance in order to affect the ear. It was therefore supposed that, if we could lead to the ear air that was directly in contact with the illuminated surface, louder sounds might be obtained, and solid masses be found to be as sonorous as thin diaphragms. The first experiments made to verify

* A paper read before the National Academy of Arts and Sciences, April 21, 1881. (From author's advance-sheets.)

† "Proceedings of American Association for the Advancement of Science," August 27, 1880; see, also, "American Journal of Science," vol. xx, p. 305; "Journal of the American Electrical Society," vol. iii, p. 3; "Journal of the Society of Telegraph Engineers and Electricians," vol. ix, p. 404; "Annales de Chimie et de Physique," vol. xxi.

this hypothesis pointed toward success. A beam of sunlight was focused into one end of an open tube, the ear being placed at the other end. Upon interrupting the beam, a clear, musical tone was heard, the pitch of which depended upon the frequency of the interruption of the light and the loudness upon the material composing the tube.

At this stage our experiments were interrupted, as circumstances called me to Europe.

While in Paris a new form of the experiment occurred to my mind, which would not only enable us to investigate the sounds produced by masses, but would also permit us to test the more general proposition that *sonorousness, under the influence of intermittent light, is a property common to all matter.*

The substance to be tested was to be placed in the interior of a transparent vessel, made of some material which (like glass) is transparent to light, but practically opaque to sound.

Under such circumstances the light could get in, but the sound produced by the vibration of the substance could not get out. The audible effects could be studied by placing the ear in communication with the interior of the vessel by means of a hearing-tube.

Some preliminary experiments were made in Paris to test this idea, and the results were so promising that they were communicated to the French Academy on October 11, 1880, in a note read for me by M. Antoine Breguet.* Shortly afterward I wrote to Mr. Tainter, suggesting that he should carry on the investigation in America, as circumstances prevented me from doing so myself in Europe. As these experiments seem to have formed the common starting-point for a series of independent researches of the most important character, carried on simultaneously, in America by Mr. Tainter, and in Europe by M. Mercadier,† Professor Tyndall,‡ W. E. Röntgen,* and W. H. Preece,‖ I may be permitted to quote from my letter to Mr. Tainter the passage describing the experiments referred to:

METROPOLITAN HOTEL, RUE CAMBON, PARIS, *November* 2, 1880.

DEAR MR. TAINTER: . . . I have devised a method of producing sounds by the action of an intermittent beam of light from substances that can not be obtained in the shape of thin diaphragms or in the tubular form; indeed, the method is specially adapted to testing the generality of the phenomenon we have discovered, as it can be adapted to solids, liquids, and gases.

Place the substance to be experimented with in a glass test-tube, connect a

* "Comptes Rendus," vol. cxl, p. 595.

† "Notes on Radiophony" ("Comptes Rendus," December 6 and 13, 1880; February 21 and 28, 1881). See, also, "Journal de Physique," vol. x, p. 53.

‡ "Action of an Intermittent Beam of Radiant Heat upon Gaseous Matter" ("Proceedings of the Royal Society," January 13, 1881, vol. xxxi, p. 307).

* "On the Tones which arise from the Intermittent Illumination of a Gas." (See "Annalen der Physik und Chemie," January, 1881, No. 1, p. 155.)

‖ "On the Conversion of Radiant Energy into Sonorous Vibration" ("Proceedings of the Royal Society," March 10, 1881, vol. xxxi, p. 506).

rubber tube with the mouth of the test-tube, placing the other end of the pipe to the ear. Then focus the intermittent beam upon the substance in the tube. I have tried a large number of substances in this way with great success, although it is extremely difficult to get a glimpse of the sun here, and when it does shine the intensity of the light is not to be compared with that to be obtained in Washington. I got splendid effects from crystals of bichromate of potash, crystals of sulphate of copper, and from tobacco-smoke. A whole cigar placed in the test-tube produced a very loud sound. I could not hear anything from plain water, but when the water was discolored with ink a feeble sound was heard. I would suggest that you might repeat these experiments and extend the results. . . .

Upon my return to Washington in the early part of January,* Mr. Tainter communicated to me the results of the experiments he had made in my laboratory during my absence in Europe.

He had commenced by examining the sonorous properties of a vast number of substances inclosed in test-tubes in a simple empirical search for loud effects. He was thus led gradually to the discovery that cotton-wool, worsted, silk, and fibrous materials generally, produced much louder sounds than hard, rigid bodies like crystals, or diaphragms such as we had hitherto used.

In order to study the effects under better circumstances, he inclosed his materials in a conical cavity in a piece of brass closed by a flat plate of glass. A brass tube leading into the cavity served for connection with the hearing-tube. When this conical cavity was stuffed with worsted or other fibrous materials the sounds produced were much louder than when a test-tube was employed. This form of receiver is shown in Fig. 1.

FIG. 1.

Mr. Tainter next collected silks and worsteds of different colors, and speedily found that the darkest shades produced the best effects. Black worsted especially gave an extremely loud sound.

As white cotton-wool had proved itself equal, if not superior, to any other white fibrous material before tried, he was anxious to obtain colored specimens for comparison. Not having any at hand, however, he tried the effect of darkening some cotton-wool with lampblack.

* On the 7th of January.

Such a marked reënforcement of the sound resulted that he was induced to try lampblack alone.

About a teaspoonful of lampblack was placed in a test-tube and exposed to an intermittent beam of sunlight. The sound produced was much louder than any heard before.

Upon smoking a piece of plate-glass, and holding it in the intermittent beam with the lampblack surface toward the sun, the sound produced was loud enough to be heard, with attention, in any part of the room. With the lampblack surface turned from the sun, the sound was much feebler.

Mr. Tainter repeated these experiments for me immediately upon my return to Washington, so that I might verify his results.

Upon smoking the interior of the conical cavity shown in Fig. 1, and then exposing it to the intermittent beam, with the glass lid in position as shown, the effect was perfectly startling. The sound was so loud as to be actually painful to an ear placed closely against the end of the hearing-tube.

The sounds, however, were sensibly louder when we placed some smoked wire-gauze in the receiver, as illustrated in the drawing (Fig. 1).

When the beam was thrown into a resonator, the interior of which had been smoked over a lamp, most curious alternations of sound and silence were observed. The interrupting disk was set rotating at a high rate of speed, and was then allowed to come gradually to rest. An extremely feeble musical tone was at first heard, which gradually fell in pitch as the rate of interruption grew less. The loudness of the sound produced varied in the most interesting manner. Minor reënforcements were constantly occurring, which became more and more marked as the true pitch of the resonator was neared. When at last the frequency of interruption corresponded to the frequency of the fundamental of the resonator, the sound produced was so loud that it might have been heard by an audience of hundreds of people.

The effects produced by lampblack seemed to me to be very extraordinary, especially as I had a distinct recollection of experiments made in the summer of 1880 with smoked diaphragms, in which no such reënforcement was noticed.

Upon examining the records of our past photophonic experiments we found in vol. vii, p. 57, the following note:

> Experiment V.—Mica diaphragm covered with lampblack on side exposed to light.
>
> Result: distinct sound about same as without lampblack.—A. G. B., *July* 18, 1880.
>
> Verified the above, but think it somewhat louder than when used without lampblack.—S. T., *July* 18, 1880.

Upon repeating this old experiment we arrived at the same result as that noted. Little if any augmentation of sound resulted from

smoking the mica. In this experiment the effect was observed by placing the mica diaphragm against the ear, and also by listening through a hearing-tube, one end of which was closed by the diaphragm. The sound was found to be more audible through the free air when the ear was placed as near to the lampblack surface as it could be brought without shading it.

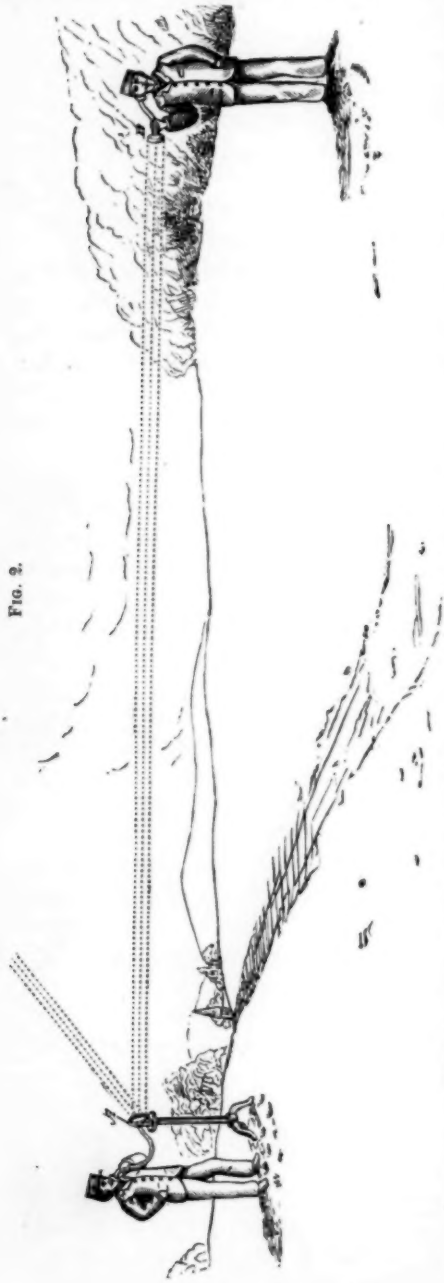


FIG. 2.

At the time of my communication to the American Association I had been unable to satisfy myself that the substances which had become sonorous under the direct influence of intermittent sunlight were capable of reproducing the sounds of articulate speech under the action of an undulatory beam from our photophonic transmitter. The difficulty in ascertaining this will be understood by considering that the sounds emitted by thin diaphragms and tubes were so feeble that it was impracticable to produce audible effects from substances in these conditions at any considerable distance away from the transmitter; but it was equally impossible to judge of the effects produced by our articulate transmitter at a short distance away, because the speaker's voice was directly audible through the air. The extremely loud sounds produced from lampblack have enabled us to demonstrate the feasibility of using this substance in an articulating photophone in place of the electrical receiver formerly employed.

The drawing (Fig. 2) illustrates the mode in which the ex-

periment was conducted. The diaphragm of the transmitter (A) was only five centimetres in diameter, the diameter of the receiver (B) was

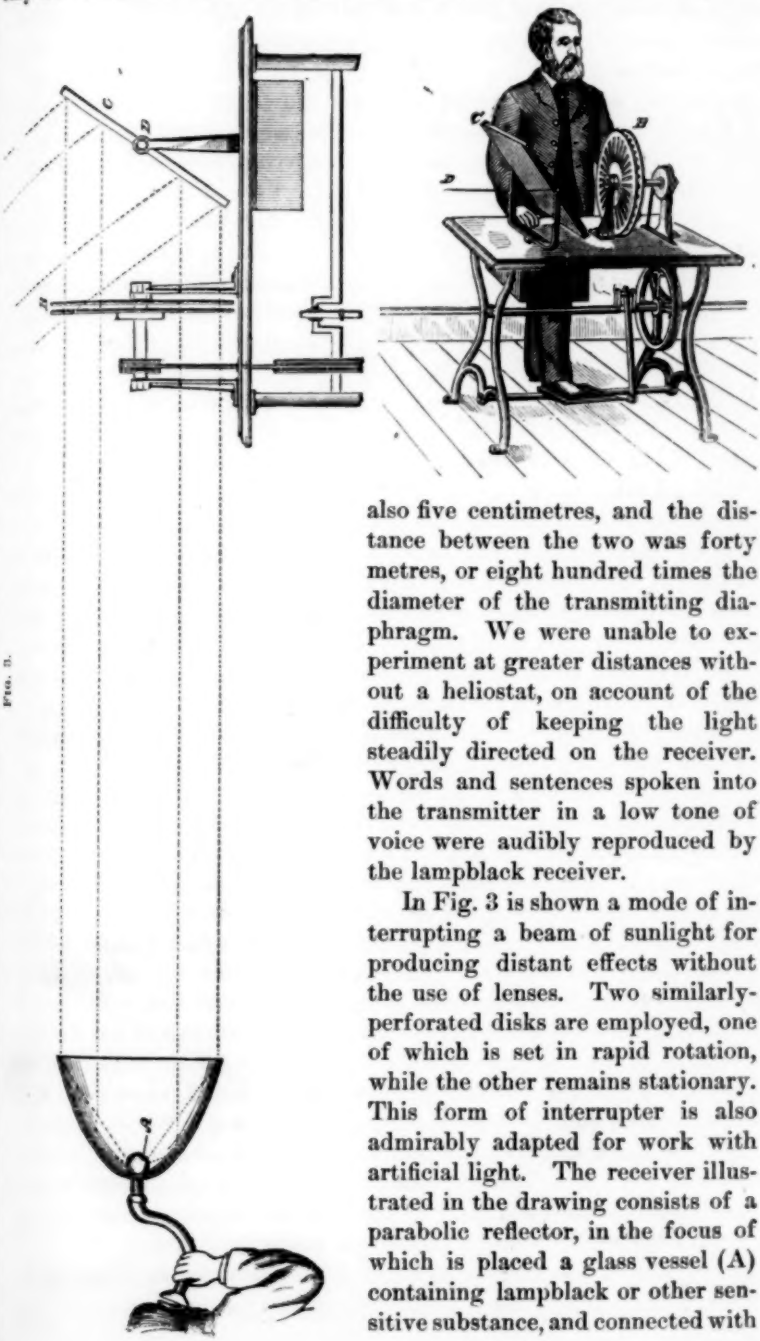


FIG. 2.

also five centimetres, and the distance between the two was forty metres, or eight hundred times the diameter of the transmitting diaphragm. We were unable to experiment at greater distances without a heliostat, on account of the difficulty of keeping the light steadily directed on the receiver. Words and sentences spoken into the transmitter in a low tone of voice were audibly reproduced by the lampblack receiver.

In Fig. 3 is shown a mode of interrupting a beam of sunlight for producing distant effects without the use of lenses. Two similarly-perforated disks are employed, one of which is set in rapid rotation, while the other remains stationary. This form of interrupter is also admirably adapted for work with artificial light. The receiver illustrated in the drawing consists of a parabolic reflector, in the focus of which is placed a glass vessel (A) containing lampblack or other sensitive substance, and connected with

a hearing-tube. The beam of light is interrupted by its passage through the two slotted disks shown at B, and in operating the instrument musical signals like the dots and dashes of the Morse alphabet are produced from the sensitive receiver (A) by slight motions of the mirror (C) about its axis (D).

In place of the parabolic reflector shown in the figure a conical reflector like that recommended by Professor Sylvanus Thompson* can be used, in which case a cylindrical glass vessel would be preferable to the flask (A) shown in the figure.

In regard to the sensitive materials that can be employed, our experiments indicate that in the case of solids the physical condition and the color are two conditions that markedly influence the intensity of the sonorous effects. *The loudest sounds are produced from substances in a loose, porous, spongy condition, and from those that have the darkest or most absorbent colors.*

The materials from which the best effects have been produced are cotton-wool, worsted, fibrous materials generally, cork, sponge, platinum, and other metals in a spongy condition, and lampblack.

The loud sounds produced from such substances may perhaps be explained in the following manner: Let us consider, for example, the case of lampblack—a substance which becomes heated by exposure to rays of all refrangibility. I look upon a mass of this substance as a sort of sponge, with its pores filled with air instead of water. When a beam of sunlight falls upon this mass, the particles of lampblack are heated, and consequently expand, causing a contraction of the air-spaces or pores among them.

Under these circumstances a pulse of air should be expelled, just as we would squeeze out water from a sponge.

The force with which the air is expelled must be greatly increased by the expansion of the air itself, due to contact with the heated particles of lampblack. When the light is cut off, the converse process takes place. The lampblack particles cool and contract, thus enlarging the air spaces among them, and the inclosed air also becomes cool. Under these circumstances a partial vacuum should be formed among the particles, and the outside air would then be absorbed, as water is by a sponge when the pressure of the hand is removed.

I imagine that in some such manner as this a wave of condensation is started in the atmosphere each time a beam of sunlight falls upon lampblack, and a wave of rarefaction is originated when the light is cut off. *We can thus understand how it is that a substance like lampblack produces intense sonorous vibrations in the surrounding air, while at the same time it communicates a very feeble vibration to the diaphragm or solid bed upon which it rests.*

This curious fact was independently observed in England by Mr. Preece, and it led him to question whether, in our experiments with

* "Philosophical Magazine," April, 1881, vol. xi, p. 286.

thin diaphragms, the sound heard was due to the vibration of the disk or (as Professor Hughes had suggested) to the expansion and contraction of the air in contact with the disk confined in the cavity behind the diaphragm. In his paper read before the Royal Society on the 10th of March, Mr. Preece describes experiments from which he claims to have proved that the effects are wholly due to the vibrations of the confined air, and that the *disks do not vibrate at all.*

I shall briefly state my reasons for disagreeing with him in this conclusion :

1. When an intermittent beam of sunlight is focused upon a sheet of hard rubber or other material, a musical tone can be heard, not only by placing the ear immediately behind the part receiving the beam, but by placing it against any portion of the sheet, even though this may be a foot or more from the place acted upon by the light.

2. When the beam is thrown upon the diaphragm of a "Blake transmitter," a loud musical tone is produced by a telephone connected in the same galvanic circuit with the carbon button (A), Fig. 4. Good effects are also produced when the carbon button (A) forms, with the battery (B), a portion of the primary circuit of an induction-coil, the telephone (C) being placed in the secondary circuit.

In these cases the wooden box and mouth-piece of the transmitter should be removed, so that no air-cavities may be left on either side of the diaphragm.

It is evident, therefore, that in the case of thin disks a real vibration of the diaphragm is caused by the action of the intermittent beam, independently of any expansion and contraction of the air confined in the cavity behind the diaphragm.

Lord Rayleigh has shown mathematically that a to-and-fro vibration, of sufficient amplitude to produce an audible sound, would result from a periodical communication and abstraction of heat, and he says : "We may conclude, I think, that there is at present no reason for discarding the obvious explanation that the sounds in question are due to the bending of the plates under unequal heating" ("Nature," vol. xxiii, p. 274). Mr. Preece, however, seeks to prove that the sonorous effects can not be explained upon this supposition ; but his experimental proof is inadequate to support his conclusion. Mr. Preece expected that, if Lord Rayleigh's explanation was correct, the expansion and contraction of a thin strip under the influence of an intermittent beam could be caused to open and close a galvanic circuit so as to produce a musical tone from a telephone in the circuit. But this was an inadequate way to test the point at issue, for Lord Rayleigh has shown ("Proceedings of the Royal Society," 1877) that an audible sound can be produced by a vibration whose amplitude is *less than a ten-millionth of a centimetre*, and certainly such a vibration as that would not have sufficed to operate a "make-and-break contact" like that used by Mr. Preece. The negative results obtained by him can not, therefore, be considered conclusive.

The following experiments (devised by Mr. Tainter) have given re-

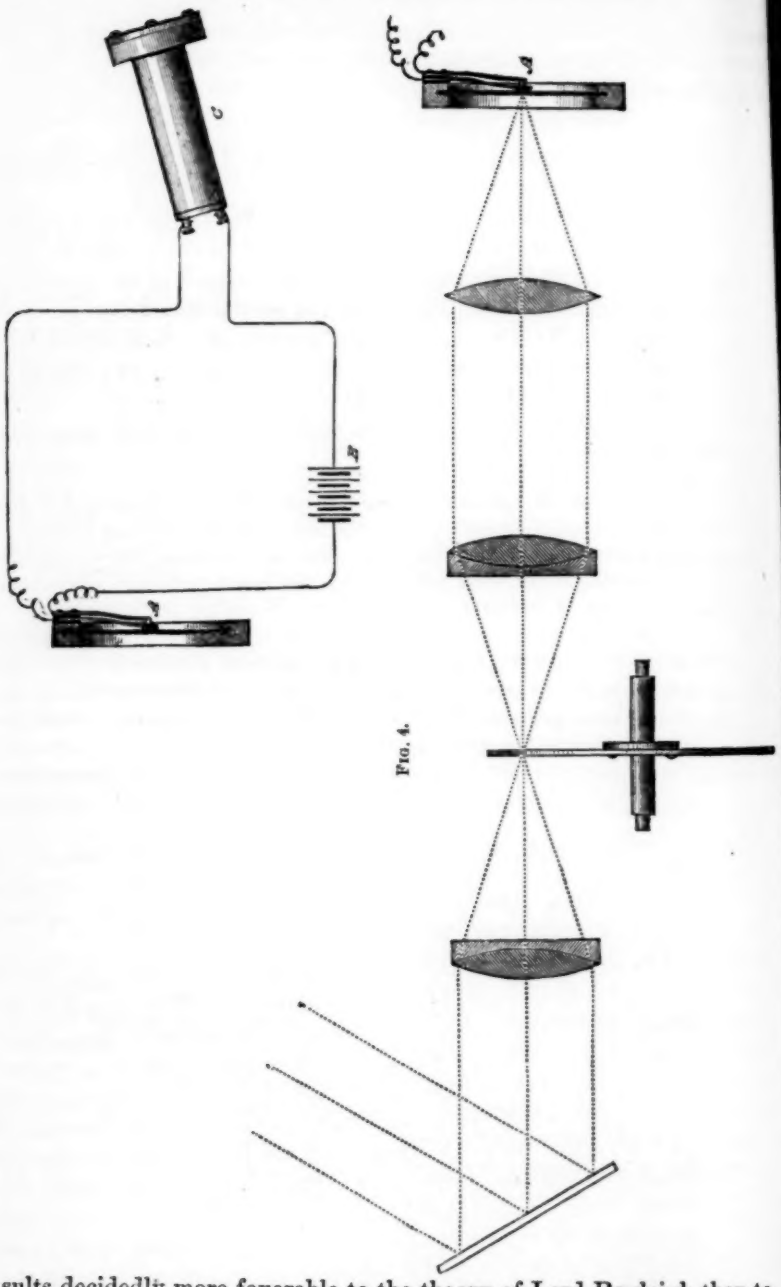


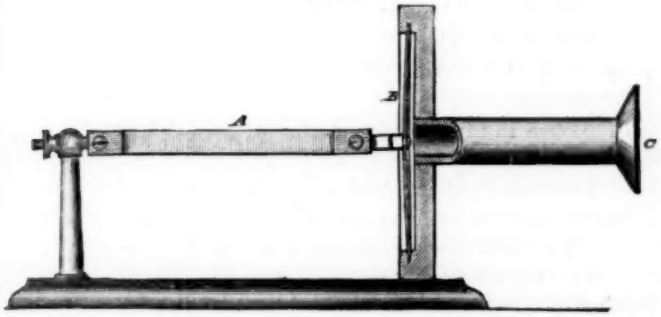
FIG. 4.

sults decidedly more favorable to the theory of Lord Rayleigh than to that of Mr. Preece:

1. A strip (A) similar to that used in Mr. Preece's experiment was attached firmly to the center of an iron diaphragm (B), as shown in Fig. 5, and was

then pulled taut at right angles to the plane of the diaphragm. When the intermittent beam was focused upon the strip (A), a clear musical tone could be heard by applying the ear to the hearing-tube (C).

FIG. 5.



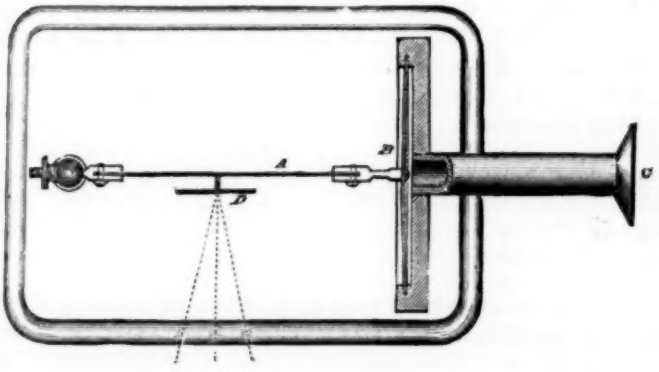
This seemed to indicate a rapid expansion and contraction of the substance under trial.

But a vibration of the diaphragm (B) would also have resulted if the thin strip (A) had acquired a to-and-fro motion, due either to the direct impact of the beam or to the sudden expansion of the air in contact with the strip.

2. To test whether this had been the case, an additional strip (D) was attached by its central point only to the strip under trial, and was then submitted to the action of the beam, as shown in Fig. 6.

It was presumed that, if the vibration of the diaphragm (B) had been due to a *pushing force* acting on the strip (A), the addition of the strip (D) would not interfere with the effect; but, if, on the other hand, it had been due to the longi-

FIG. 6.



tudinal expansion and contraction of the strip (A), the sound would cease, or at least be reduced. The beam of light falling upon the strip (D) was now interrupted as before by the rapid rotation of a perforated disk, which was allowed to come gradually to rest.

No sound was heard excepting at a certain speed of rotation, when a feeble musical tone became audible.

This result is confirmatory of the first.

The audibility of the effect at a particular rate of interruption suggests the explanation that the strip D had a normal rate of vibration of its own.

When the frequency of the interruption of the light corresponded to this, the strip was probably thrown into vibration after the manner of a tuning-fork, in which case a to-and-fro vibration would be propagated down its stem or central support to the strip (A).

This indirectly proves the value of the experiment.

The list of solid substances that have been submitted to experiment in my laboratory is too long to be quoted here, and I shall merely say that we have not yet found one solid body that has failed to become sonorous under proper conditions of experiment.*

EXPERIMENTS WITH LIQUIDS.—The sounds produced by liquids are much more difficult to observe than those produced by solids. The high absorptive power possessed by most liquids would lead one to expect intense vibrations from the action of intermittent light; but the number of sonorous liquids that have so far been found is extremely limited, and the sounds produced are so feeble as to be heard only by the greatest attention and under the best circumstances of experiment. In the experiments made in my laboratory, a very long test-tube was filled with the liquid under examination, and a flexible rubber tube was slipped over the mouth far enough down to prevent the possibility of any light reaching the vapor above the surface. Precautions were also taken to prevent reflection from the bottom of the test-tube. An intermittent beam of sunlight was then focused upon the liquid in the middle portion of the test-tube by means of a lens of large diameter.

RESULTS.

Clear water	No sound audible.
Water discolored by ink	Feeble sound.
Mercury	No sound heard.
Sulphuric ether*	Feeble but distinct sound.
Ammonia	" " " "
Ammonio-sulphate of copper	" " " "
Writing-ink	" " " "
Indigo in sulphuric acid	" " " "
Chloride of copper*	" " " "

The liquids distinguished by an asterisk gave the best sounds.

Acoustic vibrations are always much enfeebled in passing from liquids to gases, and it is probable that a form of experiment may be devised which will yield better results by communicating the vibrations of the liquid to the ear through the medium of a solid rod.

* Carbon and thin microscope-glass are mentioned in my Boston paper as non-responsive, and powdered chlorate of potash in the communication to the French Academy ("Comptes Rendus," vol. cxl, p. 595). All these substances have since yielded sounds under more careful conditions of experiment.

EXPERIMENTS WITH GASEOUS MATTER.—On the 29th of November, 1880, I had the pleasure of showing to Professor Tyndall, in the laboratory of the Royal Institution, the experiments described in the letter to Mr. Tainter from which I have quoted above; and Professor Tyndall at once expressed the opinion that the sounds were due to rapid changes of temperature in the body submitted to the action of the beam. Finding that no experiments had been made at that time to test the sonorous properties of different gases, he suggested filling one test-tube with the vapor of sulphuric ether (a good absorbent of heat), and another with the vapor of bisulphide of carbon (a poor absorbent), and he predicted that if any sound were heard it would be louder in the former case than in the latter.

The experiment was immediately made, and the result verified the prediction.

Since the publication of the memoirs of Röntger * and Tyndall † we have repeated these experiments, and have extended the inquiry to a number of other gaseous bodies, obtaining in every case similar results to those noted in the memoirs referred to.

The vapors of the following substances were found to be highly sonorous in the intermittent beam: Water-vapor, coal-gas, sulphuric ether, alcohol, ammonia, amylene, ethyl bromide, diethylamene, mercury, iodine, and peroxide of nitrogen. The loudest sounds were obtained from iodine and peroxide of nitrogen.

I have now shown that sounds are produced by the direct action of intermittent sunlight from substances in every physical condition (solid, liquid, and gaseous), and the probability is, therefore, very greatly increased that sonorousness under such circumstances will be found to be a universal property of matter.

[*To be continued.*] 824

THE DEVELOPMENT OF POLITICAL INSTITUTIONS.

BY HERBERT SPENCER.

VII.—COMPOUND POLITICAL HEADS.

IN the preceding chapter on chiefs and kings, we traced the development of the first element in that triune political structure which everywhere shows itself at the outset. We pass now to the development of the second element—the group of leading men among whom the chief is, at first, merely the most conspicuous. Under what conditions this so evolves as to subordinate the other two, what causes

* "Annalen der Physik und Chemie," 1881, No. 1, p. 155.

† "Proceedings of the Royal Society," vol. xxxi, p. 307.

make it narrower, and what causes widen it until it passes into the third, we have here to observe.

If the innate feelings and aptitudes of a race have large shares in determining the size and cohesions of the social groups it forms, still more must they have large shares in determining the relations which arise among the members of such groups. While the mode of life followed tends to generate this or that political structure, its effects are always complicated by the effects of inherited character. Whether or not the primitive state, in which governing power is equally distributed among all warriors or all elders, passes into the state in which governing power is monopolized by one, depends, in part, on the life of the group as predatory or peaceful, and in part on the natures of its members as prompting them to oppose dictation more or less doggedly. A few facts will make this clear.

The Arafuras (Papuan-Islanders) who "live in peace and brotherly love," have no other "authority among them than the decisions of their elders." Among the harmless Todas "all disputes and questions of right and wrong are settled either by arbitration or by a Punchayet—i. e., a council of five." Of the Bodo and Dhimáls, described as averse to military service, and "totally free from arrogance, revenge, cruelty, and *fierté*," we read that though each of their small communities has a nominal head who pays the tribute on its behalf, yet he is without power, and "disputes are settled among themselves by juries of elders." In these cases, besides absence of the causes which bring about chiefly supremacy, may be noted the presence of causes which directly hinder it. The Papuans generally, typified by the Arafuras above named, while they are described by Modera, Ross, and Kolff, as "good-natured," "of a mild disposition," kind and peaceful to strangers, are said by Earl to be unfit for military action; "their impatience of control . . . utterly precludes that organization which would enable" the Papuans "to stand their ground against encroachments." The Bodo and Dhimáls while "they are void of all violence toward their own people or toward their neighbors," also "resist injunctions, injudiciously urged, with dogged obstinacy." And of a kindred "very fascinating people," the Lepchas, amiable, peaceful, kind, as travelers unite in describing them, and who will not take service as soldiers, we are told that they will "undergo great privation rather than submit to oppression or injustice."

Where the innate tendency to resist coercion is strong, we find this uncentralized political organization maintained, notwithstanding the warlike activities which tend to initiate settled chieftainship. The Nagas "acknowledge no king among themselves, and deride the idea of such a personage among others"; their "villages are continually at feud"; "every man being his own master, his passions and inclinations are ruled by his share of brute force." And then we further find that "petty disputes and disagreements about property are settled

by a council of elders, the litigants voluntarily submitting to their arbitration. But, correctly speaking, there is not the shadow of a constituted authority in the Naga community, and, wonderful as it may seem, this want of government does not lead to any marked degree of anarchy and confusion." Similarly among such peoples, remote in type, as many of the warlike tribes of North America. Speaking of these Indians in general, Schoolcraft says that "they all wish to govern, and not to be governed. Every Indian thinks he has a right to do as he pleases, and that no one is better than himself; and he will fight before he will give up what he thinks right." Of the Comanches, as an example, he remarks that "the democratic principle is strongly implanted in them"; and that for governmental purposes "public councils are held at regular intervals during the year." Further, we read that in districts of ancient Central America there existed somewhat more advanced societies which, though warlike, were impelled by a kindred jealousy to provide against monopoly of power. The government was by an elective council of old men who appointed a war-chief; and this war-chief, "if suspected of plotting against the safety of the commonwealth, or for the purpose of securing supreme power in his own hands, was rigorously put to death by the council."

Though the specialities of character which thus lead certain kinds of men in early stages to originate compound political headships, and to resist, even under the stress of war, the rise of single political headships, are innate, we are not without clews to the circumstances which have made them innate; and, with a view to interpretations presently to be made, it will be useful to glance at these. The Comanches and kindred tribes, roaming about in small bands, active and skillful horsemen, have, through long-past periods, been so conditioned as to make coercion of one man by another difficult. So, too, has it been, though in another way, with the Nagas. "They inhabit a rough and intricate mountain-range"; and their villages are perched "on the crests of ridges." Again, very significant evidence is furnished by an incidental remark of Captain Burton to the effect that in Africa, as in Asia, there are three distinctly marked forms of government—military despotisms, feudal monarchies, and rude republics; the rude republics being those formed by "the Bedouin tribes, the hill people, and the jungle races." Clearly, the names of these last show that they inhabit regions which, hindering by their physical characters a centralized form of government, favor a more diffused form of government, and the less decided political subordination which is its concomitant.

These facts are obviously related to certain other facts with which they must be joined. Already evidence has been given that it is relatively easy to form a large society if the country is one within which all parts are readily accessible, while it has barriers through which exit is difficult; and that, conversely, formation of a large society is prevented, or greatly delayed, by difficulties of communication within

the occupied area, and by facilities of escape from it. But, as we now see, not only is political integration under its primary aspect of increasing mass hindered by these last-named physical conditions, but there is hindrance to the development of a more integrated form of government. That which impedes social consolidation also impedes the concentration of political power.

The truth here chiefly concerning us, however, is that the continued presence of the one or the other set of conditions fosters a character to which either the centralized or the diffused kind of political organization is appropriate. Existence, generation after generation, in a region where despotic control has arisen, produces an adapted type of nature; partly by daily habit and partly by survival of those most fit for living under such control. Contrariwise, in a region favoring maintenance of their independence by small groups, there is a strengthening, through successive ages, of sentiments averse to restraint; since not only are these sentiments exercised in all by resisting the efforts from time to time made to subordinate them, but, on the average, those who most pertinaciously resist are those who, remaining unsubdued, and transmitting their characters to posterity, determine the tribal character.

Having thus glanced at the effects of the factors, external and internal, as displayed in simple tribes, we shall understand how they coöperate when, by migration or otherwise, such tribes fall into circumstances which favor the growth of large societies.

The case of an uncivilized people of the nature described, who have in recent times shown what occurs when union of small groups into great ones is prompted, will best initiate the interpretation.

The Iroquois nations, each made up of many tribes previously hostile, had to defend themselves against European invaders. Combination for this purpose among these five (and finally six) nations necessitated a recognition of equality of power among them; since agreement to join would not have been arrived at had it been required that some divisions should be subject to others. The groups had to coöperate on the understanding that their "rights, privileges, and obligations" should be the same. Though the numbers of permanent and hereditary sachems appointed by the respective nations to form the Great Council, differed, yet the voices of the several nations were equal. Omitting details of the organization, we have to note first, that for many generations, notwithstanding the wars which this league carried on, its constitution remained stable—no supreme individual arose; and, second, that this equality of power among the groups coexisted with inequality within each group: the people had no share in its government.

A clew is thus furnished to the genesis of those compound headships with which ancient history familiarizes us. We are enabled to

see how there came to coexist, in the same societies, some institutions of a despotic kind, with other institutions of a kind appearing to be based on the principle of equality, and often confounded with free institutions. Let us recall the antecedents of those early European peoples who developed governments of this form.

During the wandering pastoral life, subordination to a single head, growing naturally out of fatherhood, was fostered. A recalcitrant member of any group had either to submit to the authority under which he had grown up, or, throwing off its yoke, had to leave the group and face those risks which unprotected life in the desert threatened. The establishment of this subordination was furthered by the more frequent survival of groups in which it was greatest; since, in the conflicts between groups, those of which the members were insubordinate, ordinarily being both smaller and less able to coöperate effectually, were the more likely to disappear. But now, to the fact that in such families and clans circumstances fostered obedience to the father and to the patriarch, has to be added the fact above emphasized, that circumstances also fostered the sentiment of liberty in the relations between clans. The exercise of power by one of them over another was made difficult by wide scattering and by great mobility; and with successful opposition to external coercion, or evasion of it, carried on through numberless generations, the tendency to resent and resist all strange authority was likely to become strong.

Whether, when groups thus disciplined aggregate, they assume this or that form of political organization, depends partly, as already implied, on the conditions into which they fall. Even could we omit those differences between Mongols, Semites, and Aryans, established in prehistoric times by causes unknown to us—even had complete likeness of nature been produced in them by long continuance of pastoral life—yet large societies, formed by combinations of these small ones, could be similar in type only under similar circumstances. Hence, probably, the reason why Mongols and Semites, where they have settled and multiplied, have failed to maintain the autonomies of their hordes after combination of them, and to evolve the resulting institutions. Even the Aryans, among whom chiefly the less concentrated forms of political rule have arisen, yield an illustration. Originally inheriting in common the mental traits generated during their life in the Hindoo-Koosh and its neighborhood, the different divisions of the race have developed different institutions and accompanying characters. Those of them who spread into the plains of India, where great fertility made possible a large population, to the control of which there were small physical impediments, lost their independence of nature, and did not evolve political systems like those which grew up among their Western kindred, under conditions favorable for maintaining the original character.

The implication is, then, that where groups of the patriarchal type

fall into regions permitting considerable growth of population, but having physical structures which impede the centralization of power, compound political headships will arise, and for a time sustain themselves, through coöperation of the two factors—independence of local groups and need for union in war. Let us consider some examples.

The island of Crete has numerous high mountain-valleys containing good pasturage, and provides many seats for strongholds—seats which ruins prove that the ancient inhabitants utilized. Similarly with the mainland of Greece. A complicated mountain system cuts off its parts from one another and renders each difficult of access. Especially is this so in the Peloponnesus; and, above all, in the part occupied by the Spartans. It has been remarked that the state which possesses both sides of Taygetus has it in its power to be master of the peninsula: "It is the Acropolis of the Peloponnese, as that country is of the rest of Greece."

When, over the earlier inhabitants, there came the successive waves of Hellenic conquerors, these brought with them the type of nature and organization common to the Aryans, displaying the united traits above described. Such a people, taking possession of such a land, inevitably fell in course of time "into as many independent clans as the country itself was divided by its mountain-chains into valleys and districts." From separation there resulted alienation; so that those remote from one another, becoming strangers, became enemies. In early Greek times the clans, occupying mountain villages, were so liable to incursions from one another that the planting of fruit-trees was a waste of labor. There existed a state like that seen at present among such Indian hill tribes as the Nagas.

Though preserving the tradition of a common descent, and owning allegiance to the oldest male representative of the patriarch, a people spreading over a region which thus cut off from one another even adjacent small groups, and still more those remoter clusters of groups arising in course of generations, would inevitably become disunited in government: subjection to a general head would be more and more difficult to maintain, and subjection to local heads would alone continue practicable. Moreover, there must arise, under such conditions, increasing causes of insubordination, as well as great difficulties in maintaining subordination. When the various branches of a common family spread into localities so shut off from one another as to prevent intercourse, their respective histories, and the lines of descent of their respective heads, must become unknown, or but partially known, to one another; and claims to supremacy made now by this local head and now by that are certain to be disputed. When we remember how, even in settled societies having records, there have been perpetual conflicts about rights of succession, and how, down to our own day, there are frequent lawsuits to decide on heirships to titles and proper-

ties, we can not but infer that, in a state like that of the early Greeks, the difficulty of establishing the legitimacy of general headships, conspiring with the desire to assert independence and the ability to maintain it, inevitably entailed lapse into numerous local headships. Of course, under conditions varying in each locality, splittings-up of wider governments into narrower went to different extents; and, naturally, too, reëstablishments of wider governments or extensions of narrower ones in some cases took place. But, generally, the tendency under such conditions must have been to form small independent groups, severally having the patriarchal type of organization. Hence, then, the decay of such kingships as are implied in the "Iliad." As Grote writes, "When we approach historical Greece, we find that (with the exception of Sparta) the primitive, hereditary, unresponsible monarch, uniting in himself all the functions of government, has ceased to reign." *

But now what will happen when a cluster of clans of common descent, which have become independent and hostile, are simultaneously endangered by enemies to whom they are not at all akin, or but remotely akin? Habitually, they will sink their differences and coöperate for defense. But on what terms will they coöperate? Even among friendly groups joint action would be hindered if some claimed supremacy; and, among groups having outstanding feuds, there could be no joint action save on a footing of equality. The common defense would, therefore, be directed by a body formed of the heads of the coöperating small societies; and, if the coöperation for defense were prolonged, or became changed by success into coöperation for offense, this temporary controlling body would tend to become a permanent one holding the small societies together. The special characters of this compound head would, of course, vary with the circumstances. Where the traditions of the united clans agreed in identifying some one chief as the lineal representative of the original patriarch or hero, from whom all descended, precedence and some extra authority would

* While I am writing, the just-issued third volume of Mr. Skene's "Celtic Scotland" supplies me with an instructive illustration of the process above indicated. From his account it appears that the original Celtic tribes which formed the earldoms of Moray, Buchan, Athol, Angus, Menteith, became broken up into clans; and how influential was the physical character of the country in producing this result, we are shown by the fact that this change took place in the parts of them which fell within the Highland country. Describing the smaller groups which resulted, Mr. Skene says: "While the clan, viewed as a single community, thus consisted of the chief, with his kinsmen to a certain limited degree of relationship; the commonalty who were of the same blood, who all bore the same name, and his dependents, consisting of subordinate septs of native men, who did not claim to be of the blood of the chief, but were either probably descended from the more ancient occupiers of the soil, or were broken men from other clans, who had taken protection with him. . . . Those kinsmen of the chief who acquired the property of their land founded families. . . . The most influential of these was that of the oldest cadet in the family which had been longest separated from the main stem, and usually presented the appearance of a rival house little less powerful than that of the chief."

be permitted to him. Where claims derived from descent were disputed, personal superiority or election would determine which member of the compound head should take the lead. If within each of the component groups the power of its chief was unqualified, there would result from union of such chiefs a close oligarchy; while the closeness of the oligarchy would become less in proportion as recognition of the authority of each chief, given by nearness in blood to the divine or semi-divine ancestor, diminished. And in cases where there came to be incorporated numerous aliens, owing allegiance to the heads of none of the component groups, there would come into play influences tending still more to widen the oligarchy.

Such, we may conclude, were the origins of those compound headships of the Greek states which existed at the beginning of the historic period. In Crete, where there survived the tradition of primitive kingship, but where dispersion and subdivision of clans had brought about a condition in which "different towns carried on open feuds," there were "patrician houses, deriving their rights from the early ages of royal government," who continued "to retain possession of the administration." In Corinth, the line of Herakleid kings "subsides gradually, through a series of empty names, into the oligarchy denominated Bacchiadæ. . . . The persons so named were all accounted descendants of Herakles, and formed the governing caste in the city." So was it with Megara. According to tradition, this arose by combination of several villages inhabited by kindred tribes, which, originally in antagonism with Corinth, had probably, in the course of this antagonism, become consolidated into an independent state. And at the opening of the historic period the like had happened in Sikyon and other places. Though in Sparta kingship had survived under an anomalous form, yet the joint representatives of the primitive king, still reverenced because the tradition of their divine descent was preserved, had become little more than members of the governing oligarchy, retaining certain prerogatives. And, though it is true that in its earliest historically-known stage, the Spartan oligarchy did not present the form which would spontaneously arise from the union of the heads of clans for coöperation in war—though it had become elective within a limited class of persons—yet the fact that an age of not less than sixty was a qualification, harmonizes with the belief that it at first consisted of the heads of the respective groups, who were always the eldest sons of the eldest; and that these groups with their heads, described as having been in in pre-Lykurgean times "the most lawless of all the Greeks," became united by that continuous militant life which distinguished them.*

* As bearing on historical interpretations at large, and especially on interpretations to be made in this work, let me point out further reasons than those given by Grote and others for rejecting the tradition that the Spartan constitution was the work of Lykurgus. The universal tendency to ascribe an effect to the most conspicuous proximate cause is

The Romans exemplify the rise of a compound headship under conditions which, though partially different from those the Greeks were subject to, were allied fundamentally. In its earliest-known state, Latium was occupied by village-communities, which were united into cantons; while these cantons formed a league headed by Alba—a canton regarded as the oldest and most eminent. This combination was for joint defense; as is shown by the fact that each group of clan-villages composing a canton had an elevated stronghold in common, and also by the fact that the league of cantons had for its center and place of refuge Alba, the most strongly placed as well as the oldest. The component cantons of the league were so far independent that there were wars between them; whence we may infer that when they cooperated for joint defense it was on substantially equal terms. Thus, before Rome existed, the people who formed it had been habituated to a kind of life such that, with great subordination in each family and clan, and partial subordination within each canton (which was governed by a prince, council of elders, and assembly of warriors), there went a union of heads of cantons, who were in no degree subordinate one to another. When the inhabitants of three of these cantons, the Ramnians, Tities, and Luceres, began to occupy the tract on which Rome stands, they brought with them their political organization. The oldest Roman patricians bore the names of rural clans belonging to these cantons. Whether, when seating themselves on the Palatine Hills and on the Quirinal, they preserved their cantonal divisions, is not clear, though it seems probable *a priori*. But, however this may be, there is proof that they fortified themselves against one another, as

especially strong where the effect is one of which the causation is involved. Our own time has furnished an illustration in the ascription of Corn-law Repeal to Sir Robert Peel, and after him to Messrs. Cobden and Bright, leaving Colonel Thompson unnamed. In the next generation the man who for a time carried on the fight single-handed, and forged sundry of the weapons used by the victors, will be unheard of in connection with it. It is not enough, however, to suspect that Lykurgus was simply the finisher of other men's work. We may reasonably suspect that the work was that of no man, but simply that of the needs and conditions. This may be seen in the institution of the public mess. If we ask what will happen with a small people who, for generations spreading as conquerors, have a contempt for all industry, and who, when not at war, pass their time in exercises fitting them for war, it becomes manifest that at first the daily assembling to carry on these exercises will entail the daily bringing of provisions by each. As happens in those picnics in which all who join contribute to the common repast, a certain obligation respecting qualities and quantities will naturally arise—an obligation which, repeated daily, will pass from custom into law; ending in a specification of the kinds and amounts of food. Further, it is to be expected that as the law thus arises in an age when food is coarse and unvaried, the simplicity of the diet, originally unavoidable, will eventually be considered as intended—as an ascetic regimen deliberately devised. (When writing this I was not aware that, as pointed out by Professor Paley in "Fraser's Magazine," for February, 1881, that among the Greeks of later times it was common to have dinners to which each guest brought his share of provisions, and that those who contributed little and consumed much were objects of satire. This fact greatly increases the probability that the Spartan mess originated as suggested.)

well as against outer enemies. The "mount-men" of the Palatine and the "hill-men" of the Quirinal were habitually at feud; and, even among the minor divisions of those who occupied the Palatine, there were dissensions. As Mommsen says, primitive Rome was "rather an aggregate of urban settlements than a single city." And that the clans who formed these settlements brought with them their enmities is to be inferred from the fact that not only did they fortify the hills on which they fixed themselves, but even "the houses of the old and powerful families were constructed somewhat after the manner of fortresses."

So that again, in the case of Rome, we a see a cluster of small independent communities allied in blood but partially antagonistic, which had to coöperate against enemies on such terms as all would agree to. In early Greece the means of defense were, as Grote remarks, greater than the means of attack; and it was the same in early Rome. Hence, while coercive rule within each family and small group was easy, there was difficulty in extending coercion over many groups—fortified as they were against one another. Moreover, the stringency of government within each settlement constituting the primitive city was diminished by facility of escape from one and admission into another. As we have seen among simple tribes, desertions take place when the rule is unduly harsh; and we may infer that, within each of these clustered settlements, there was a check on exercise of force by the heads of the more powerful families over those of the less powerful, caused by the fear that migration might weaken the settlement and strengthen an adjacent one. Thus the circumstances were such that when, for defense of the primitive city, coöperation became needful, the heads of the clans included in the several settlements came to have substantially equal powers. The original senate was the collective body of clan-elders; and "this assembly of elders was the ultimate holder of the ruling power": it was "an assembly of kings." At the same time, the heads of families in each clan, forming the body of burgesses, stood, for like reasons, on equal footing. Primarily for command in war, there was an elected head, who was also chief magistrate. Though not having the authority given by alleged divine descent, he had the authority given by supposed divine approval; and, himself bearing the insignia of a god, he retained till death the absoluteness appropriate to one. But, besides the fact that the choice, originally made by the senate, had to be again practically made by it in case of sudden vacancy, and besides the fact that each king, nominated by his predecessor, had to be approved by the assembled burgesses, there is the fact that his power was exclusively executive. The assembly of burgesses "was in law superior to, rather than coördinate with, the king." Further, in the last resort was exercised the still superior power of the senate, which was the guardian of the law, and could veto the joint decision of king and burgesses. Thus the con-

stitution was in essence an oligarchy of heads of clans, included in an oligarchy of heads of houses—a compound oligarchy which became unqualified when kingship was suppressed. And here should be emphasized the truth, sufficiently obvious and yet continually ignored, that the Roman Republic, which remained when the regal power ended, was quite alien in nature to those popular governments with which it has been commonly classed. The heads of clans, of which the narrower governing body was formed, as well as the heads of families which formed the wider governing body, were, indeed, jealous of one another's powers; and in so far simulated the citizens of a free state who individually maintain their equal rights. But these heads severally exercised unlimited powers over the members of their households and over their clusters of dependents. A community of which the component groups severally retained their internal autonomies, with the result that the rule within each remained absolute, was nothing but an aggregate of small despotisms. Institutions under which the head of each group, besides owning slaves, had such supremacy that his wife and children, including even married sons, had no more legal rights than cattle, and were at his mercy in life and limb, or could be sold into slavery, can be called free institutions only by those who confound similarity of external outline with similarity of internal structure.*

The formation of compound political heads in later times repeats this process in essentials, if not in details. In one way or other the result arises when a common need for defense compels coöperation, while there exists no means of securing coöperation save voluntary agreement.

Beginning with the example of Venice, we notice first that the region occupied by the ancient Veneti included the extensive marshy tract formed of the deposits brought down by several rivers to the Adriatic—a tract which, in Strabo's day, was "intersected in every quarter by rivers, streams, and morasses"; so that "Aquileia and Ravenna were then cities in the marshes." Having for their stronghold this region full of spots accessible only to inhabitants who knew the intricate ways to them, the Veneti maintained their independence, spite of the efforts of the Romans to subdue them, until the days of Cæsar. In later days kindred results were more markedly displayed in that part of this region specially characterized by inaccessibility. From the earliest times the islets, or rather mud-banks, on which Venice stands, were inhabited by a maritime people. Each islet, secure in the midst of its tortuous lagunes, had a popular gov-

* I should have thought it needless to insist on so obvious a truth, had it not been that even still there continues this identification of things so utterly different. Within these few years has been published a magazine-article by an historian, describing the corruptions of the Roman Republic during its latter days, with the appended moral that such were, and are, likely to be the results of democratic government.

ernment of annually elected tribunes. And these original governments, existing at the time when there came several thousands of fugitives, driven from the mainland by the invading Huns, survived under the form of a rude confederation. As we have seen happen in other cases, the union into which these independent little communities were forced for purposes of joint defense was disturbed by feuds; and it was only under the stress of opposition to aggressing Lombards on the one side and Slavonic pirates on the other that a general assembly of nobles, clergy, and citizens appointed a duke or doge to direct the combined forces, and to restrain internal factions; being superior to the tribunes of the united islets and subject only to this body which appointed him. What changes subsequently took place —how, beyond the restraints imposed by the general assembly, the doge was presently put under the check of two elected councilors, and on important occasions had to summon the principal citizens; how there came afterward a representative council, which underwent from time to time changes—does not now concern us. Here we have simply to note that, as in preceding cases, the component groups being favorably circumstanced for severally maintaining their independence of one another, the imperative need for union against enemies initiated a rude compound headship, which, notwithstanding the centralizing effects of war, tended to maintain itself in one or other form.

On finding allied results among men of a different race but occupying a similar region, doubts respecting the process of causation must be dissipated. On the area—half land, half sea—formed of the sediment brought down by the Rhine and adjacent rivers, there early existed scattered families. Living on isolated sand-hills, or in huts raised on piles, they were so secure amid their creeks and mud-banks and marshes, that they remained unsubdued by the Romans. Subsisting at first by fishing, with here and there such small agriculture as was possible, and eventually becoming maritime and commercial, these people, in course of time, rendered their land more habitable by damming out the sea; and they long enjoyed a partial if not complete independence. In the third century "the Low Countries contained the only free people of the German race." Especially the Frisians, more remote than the rest from invaders, "associated themselves with the tribes settled on the limits of the German Ocean, and formed with them a connection celebrated under the title of the 'Saxon League.'" Though, at a later time, the inhabitants of the Low Countries fell under the power of France, yet the nature of their habitat continued to give them such advantages in resisting foreign control that they organized themselves after their own fashion, notwithstanding interdicts. "From the time of Charlemagne the people of the ancient Menapia, now become a prosperous commonwealth, formed political associations to raise a barrier against the despotic violence of the Franks." Mean-

while the Frisians, who, after centuries of resistance to the Franks, were obliged to yield and render small tributary services, retained their internal autonomy. They formed "a confederation of rude but self-governed maritime provinces," each of these seven provinces being divided into districts severally governed by elective heads with their councils, and the whole being under a general elective head and a general council.

Of illustrations which modern times have furnished, must be named those which again show us the effects of a mountainous region. The most notable is, of course, that of Switzerland. Surrounded by forests, "among marshes and rocks and glaciers, tribes of scattered shepherds had, from the early times of the Roman conquest, found a land of refuge from the successive invaders of the rest of Helvetia." In the labyrinths of the Alps, accessible to those only who knew the ways to them, their cattle fed unseen; and against straggling bands of marauders who might discover their retreats they had great facilities for defense. These districts—which eventually became the cantons of Schwytz, Uri, and Unterwalden, originally having but one common center of meeting, but eventually, as population increased, getting three, and forming separate political organizations—long preserved complete independence. With the spread of feudal subordination throughout Europe, they became nominally subject to the Emperor; but, refusing obedience to the superiors set over them, they entered into a solemn alliance, renewed from time to time, to resist outer enemies. Details of their history need not detain us. The fact of moment is, that in these three cantons, which physically favored in so great a degree the maintenance of independence by individuals and by groups, the people, while framing for themselves free governments, united on equal terms for joint defense. And it was these typical "Swiss," as they were the first to be called, whose union formed the nucleus of the larger unions which, through varied fortunes, eventually grew up. Severally independent as were the cantons composing these larger unions, there at first existed feuds among them, which were suspended during the needs for joint defense. Only gradually did the leagues pass from temporary and unsettled forms to a permanent and settled form. Two facts of significance should be added. One is that, at a later date, a like process of resistance, federation, and emancipation from feudal tyranny, among separate communities occupying small mountain-valleys, took place in the Grisons and in the Valais—regions which, though mountainous, were more accessible than those of the Oberland and its vicinity. The other is that the more level cantons neither so early nor so completely gained their independence; and, further, that their internal constitutions were less free in form. A marked contrast existed between the aristocratic republics of Berne, Lucerne, Fribourg, and Soleure and the pure democracies of the forest cantons and the Grisons; in the last of which

"every little hamlet resting in an Alpine valley, or perched on mountain-crag, was an independent community, of which all the members were absolutely equal—entitled to vote in every assembly, and qualified for every public function. . . . Each hamlet had its own laws, jurisdiction, and privileges," the hamlets being federated into communes, the communes into districts, and the districts into a league.

Lastly, with the case of Switzerland may be associated that of San Marino—a little republic which, seated in the Apennines, and having its center on a cliff a thousand feet high, has retained its independence for fifteen centuries. Here eight thousand people are governed by a senate of sixty, and by captains elected every half year, assemblies of the whole people being called on important occasions. There is a standing army of eighteen, "taxation is reduced to a mere nothing," and officials are paid by the honor of serving.

One noteworthy difference between the compound heads arising under physical conditions of the kinds exemplified, must not be overlooked—the difference between the oligarchic form and the more or less popular form. As shown at the outset of this section, if each of the groups united by militant coöperation is despotically ruled—if the groups are severally framed on the patriarchal type, or are severally governed by men of supposed divine descent—then the compound head becomes one in which the people at large have no share. But if, as in these modern cases, patriarchal authority has decayed; or if belief in divine descent has been undermined by a creed at variance with it; or if peaceful habits have weakened that coercive authority which war ever strengthens—then the compound head is no longer an assembly of petty despots. With the progress of these changes it becomes more and more a head formed of those who exercise power not by right of position but by right of appointment.

There are other conditions which favor the rise of compound heads, temporary if not permanent: those, namely, which occur at the dissolutions of preceding organizations. Among people habituated through countless generations to personal rule, having sentiments appropriate to it, and no conception of anything else, the fall of one despot is at once followed by the rise of another; or, if a large personally-governed empire collapses, its parts severally generate governments for themselves of like kind. But, among less servile peoples, the breaking up of political systems having single heads is apt to be followed by the establishment of others having compound heads; especially where there is a simultaneous separation into parts which have not local governments of stable kinds. Under such circumstances there is a return to the primitive state. The preëxisting regulative system having fallen, the members of the community are left without any controlling power save the aggregate will; and, political organization having to commence afresh, the form first assumed is akin to that

which we see in the assembly of the savage horde, or in the modern public meeting. Whence there presently results the rule of a select few subject to the approval of the many.

In illustration may first be taken the rise of the Italian republics. When, during the ninth and tenth centuries, the German emperors, who had long been losing their power to restrain local antagonisms in Italy and the outrages of wandering robber bands, failed more than ever to protect their subject communities, and, as a simultaneous result, exercised diminished control over them, it became at once necessary and practicable for the Italian towns to develop political organizations of their own. Though in these towns there were remnants of the old Roman organization, this had obviously become effete; for, in time of danger, there was an assembling of "citizens at the sound of a great bell, to concert together the means for their common defense." Doubtless on such occasions were marked out the rudiments of those republican constitutions which afterward arose. Though it is alleged that the German emperors allowed the towns to form these constitutions, yet we may reasonably conclude, rather, that, having no care further than to get their tribute, they made no efforts to prevent the towns from forming them. And though Sismondi says of the townspeople, "ils cherchèrent à se constituer sur le modèle de la république romaine," yet we may question whether, in those dark days, the people knew enough of Roman institutions to be influenced by their knowledge. With more probability may we infer that "this meeting of all the men of the state capable of bearing arms . . . in the great square," originally called to take measures for repelling aggressors—a meeting which must, at the very beginning, have been swayed by a group of dominant citizens, and must have chosen leaders—was itself the republican government in its incipient form. Meetings of this kind, first occurring on occasions of emergency, would gradually come into use for deciding on all important public questions. Repetition would bring greater regularity in the modes of procedure, and greater definiteness in the divisions formed, ending in compound political heads, presided over by elected chiefs. And that this was the case in those early stages of which there remain but vague accounts, is shown by the fact that a similar, though somewhat more definite, process afterward occurred at Florence, when the usurping nobles were overthrown. Definite records tell us that in 1250 "the citizens assembled at the same moment in the square of Santa Croce; they divided themselves into fifty groups, of which each group chose a captain, and thus formed companies of militia: a council of these officers was the first-born authority of this newly revived republic." Clearly that sovereignty of the people which, for a time, characterized these small governments, would inevitably arise if the political form grew out of the original public meeting; while it would be unlikely to have arisen had the political form been artificially devised by a limited class.

That this interpretation harmonizes with the facts which modern times have furnished, scarcely needs pointing out. On an immensely larger scale and in ways variously modified, here by the slow collapse of an old *régime* and there by combination for war, the rise of the first French Republic and that of the American Republic have similarly shown us this tendency toward resumption of the primitive form of political organization, when a decayed or otherwise incapable government is broken up. Greatly obscured by complicating circumstances and special incidents as these transformations were, we may recognize in them the play of the same general causes.

In the last chapter we saw that, as conditions determine, the first element of the triune political structure may be differentiated from the second in various degrees — beginning with the warrior-chief slightly predominant over other warriors, and ending with the divine and absolute king, widely distinguished from the select few next to him. By the foregoing examples we are shown that the second element is, as conditions determine, variously differentiated from the third: being at the one extreme qualitatively distinguished in a high degree and divided from it by an impassable barrier, and at the other extreme almost merged into it.

Here we are introduced to the truth next to be dealt with: that not only do conditions determine the various forms which compound heads assume, but that conditions determine the various changes they undergo. There are two leading kinds of such changes—those through which the compound head passes toward a less popular form, and those through which it passes toward a more popular form. We will glance at them in this order.

Progressive narrowing of the compound head is one of the concomitants of continued military activity. Beginning with the case of Sparta, the constitution of which in its early form differed but little from that which the "Iliad" shows us existed among the Homeric Greeks, we see, in the first place, the tendency toward concentration of power in the regulation, made a century after Lykurgus, that, "in case the people decided crookedly, the senate with the kings should reverse their decisions"; and then we see that later, in consequence of the gravitation of property into fewer hands, "the number of qualified citizens went on continually diminishing": the implication being not only a relatively-increased power of the oligarchy, but, probably, a growing supremacy of the wealthier members within the oligarchy itself. Turning to the case of Rome, ever militant, we find that in course of time inequalities increased to the extent that the senate became "an order of lords, filling up its ranks by hereditary succession, and exercising collegiate misrule"; and then "out of the evil of oligarchy there emerged the still worse evil of usurpation of power by particular families." In the Italian republics, again, perpetually at

war one with another, there resulted a kindred narrowing of the governing body. The nobility, deserting their castles, began to direct "the municipal government of the cities, which consequently, during this period of the republics, fell chiefly into the hands of the superior families." Then at a later stage, when industrial progress had generated wealthy commercial classes, these, competing with the nobles for power, and finally displacing them, repeated within their respective bodies this same process. The richer guilds deprived the poorer of their shares in the choice of the ruling agencies; the privileged class was continually narrowed by disqualifying regulations; and newly risen families were excluded by those of long standing. So that, as Sismondi points out, such of the numerous Italian republics as remained nominally such at the close of the fifteenth century were, like "Sienna and Lucca, each governed by a single caste of citizens: . . . had no longer popular governments." A kindred result occurred among the Dutch. During the wars of the Flemish cities with the nobles and with one another, the relatively popular governments of the towns became narrowed. The greater guilds excluded the lesser from the ruling body, and their members "clothed in the municipal purple . . . ruled with the power of an aristocracy; . . . the local government was often an oligarchy, while the spirit of the burghers was peculiarly democratic." And with these illustrations may be joined that furnished by those Swiss cantons which, physically characterized in ways less favorable to individual independence, were at the same time given to wars, offensive as well as defensive. Berne, Lucerne, Fribourg, Soleure, acquired political constitutions in large measure oligarchic; and in "Berne, where the nobles had always been in the ascendant, the entire administration had fallen into the hands of a few families, with whom it had become hereditary."

We have next to note as a cause of progressive modification in compound heads, that, like simple heads, they are apt to be subordinated by their administrative agents. The first case to be named is one in which this effect is exemplified along with the last—the case of Sparta. Originally appointed by the kings to perform prescribed duties, the ephors first made the kings subordinate, and eventually subordinated the senate; so that they became substantially the rulers. From this we may pass to the instance supplied by Venice, where power, once exercised by the people, gradually lapsed into the hands of an executive body, the members of which, habitually reëlected, and at death replaced by their children, became an aristocracy, whence there eventually grew the Council of Ten, who were, like the Spartan ephors, "charged to guard the security of the state with a power higher than the law"; and who thus, "restrained by no rule," constituted the actual government. Through its many revolutions and changes of constitution, Florence exhibited like tendencies. The appointed administrators, now signoria, now priors, became able, during

their terms of office, to carry out their ends even to the extent of suspending the constitution—getting the forced assent of the assembled people, who were surrounded by armed men. And then, eventually, the head executive agent, nominally reëlected from time to time but practically permanent, became, in the person of Cosmo de' Medici, the founder of an inherited headship.

But the liability of the compound political head to become subject to its civil agents, is far less than its liability to become subject to its military agents. From the earliest times this liability has been exemplified and commented upon; and, familiar as it is, I must here illustrate and emphasize it, because it directly bears on one of the cardinal truths of political theory. Setting out with the Greeks we observe, in the first place, that the tyrants, by whom oligarchies were so often overthrown, had armed forces at their disposal. Either the tyrant was "the executive magistrate, upon whom the oligarchy themselves had devolved important administrative powers," or he was a demagogue, who pleaded the alleged interests of the community, "in order to surround" himself "with armed defenders"—soldiers being in either case the agents of his usurpation. And then, in the second place, we see the like done by the successful general. As Macchiavelli remarks of the Romans: "For the further abroad they [the generals] carried their arms, the more necessary such prolongations [of their commissions] appeared, and the more common they became; hence it arose, in the first place, that but a few of their citizens could be employed in the command of armies, and consequently few were capable of acquiring any considerable degree of experience or reputation; and in the next, that when a commander in chief was continued for a long time in that post, he had an opportunity of corrupting his army to such a degree that the soldiers entirely threw off their obedience to the senate, and acknowledged no authority but his. To this it was owing that Sylla and Marius found means to debauch their armies and make them fight against their country; and that Julius Cæsar was enabled to make himself absolute in Rome."

The Italian republics, again, furnish many illustrations. By the beginning of the fourteenth century, those of Lombardy "all submitted themselves to the military power of some nobles to whom they had intrusted the command of their militias, and thus all lost their liberty." Later times and nearer regions yield instances. At home Cromwell showed how the successful general tends to become autocrat. In the Netherlands the same thing was exemplified by the Van Arteveldes, father and son, and again by Maurice of Nassau; and, but for form's sake, it would be needless to name the case of Napoleon. It should be added that not only by command of armed forces is the military chief enabled to seize on supreme power, but acquired popularity, especially in a militant nation, places him in a position which makes it relatively easy to do this. Neither their own experience, nor

the experiences of other nations throughout the past, prevented the French from lately making Marshal MacMahon executive head; and even the Americans, in more than once choosing General Grant for President, proved that, predominantly industrial though their society is, militant activity promptly caused an incipient change toward the militant type, of which an essential trait is the union of civil headship with military headship.

From the influences which tend to narrow compound political headships, or change them into single ones, let us pass to the influences which tend to widen them. The case of Athens is, of course, the first to be considered. To understand this we must remember that, up to the time of Solon, democratic government did not exist in Greece. The only known forms were the oligarchic and the despotic; and in those early days, before political speculation began, it is certain that there was not recognized in theory a social form wholly unknown in practice. We have, therefore, to exclude the notion that popular government arose in Athens under the guidance of any preconceived idea. As having the same implication should be added the fact that—Athens being governed by an oligarchy at the time—the Solonian legislation served but to qualify and broaden the oligarchy and remove crying injustices. In seeking the causes which worked through Solon, and also made practicable the reorganization he initiated, we shall find them to lie in the direct and indirect influences of trade. Grote comments on "the anxiety, both of Solon and of Drako, to enforce among their fellow-citizens industrious and self-maintaining habits"—a proof that, even before Solon's time, there was in Attica little or no reprobation of "sedentary industry, which in most other parts of Greece was regarded as comparatively dishonorable." Moreover, Solon was himself in early life a trader; and his legislation "provided for traders and artisans a new home at Athens, giving the first encouragement to that numerous town-population, both in the city and in the Peiræus, which we find actually residing there in the succeeding century." The immigrants who flocked into Attica because of its greater security, Solon was anxious to turn rather to manufacturing industry than to cultivation of a soil naturally poor; and one result was "a departure from the primitive temper of Atticism, which tended both to cantonal residence and rural occupation"; while another result was to increase the number of people who stood outside those gentile and phratric divisions, which were concomitants of the patriarchal type and of personal rule. And then the constitutional changes made by Solon were in leading respects toward industrial organization. The introduction of a property-qualification for classes, instead of a birth-qualification, diminished the rigidity of the political form, since acquirement of wealth by industry, or otherwise, made possible an admission into the oligarchy, or among others of the privileged. By forbidding self-enslavement of the debtor, and by emancipating those who had been

self-enslaved, his laws added largely to the enfranchised class as distinguished from the slave-class. In another aspect this change, leaving equitable contracts untouched, prevented those inequitable contracts under which, by a lien on himself, a man gave more than an equivalent for the sum he borrowed. And, with a decreasing number of cases in which there existed the relation of master and slave, went an increasing number of cases in which benefits were exchanged by agreement. The odium attaching to that lending at interest which ended in slavery of the debtor having disappeared, legitimate lending became general and unopposed, the rate of interest was free, and accumulated capital was made available. Then, as coöperating cause, and as ever-increasing consequence, came the growth of a population favorably circumstanced for acting in concert. Urban people, who, daily in contact, can gather one another's ideas and feelings, and who, by quickly-diffused intelligence, can be rapidly assembled, can coöperate far more readily than those who are scattered through rural districts. With all which direct and indirect results of industrial development must be joined the ultimate result upon character, produced by daily fulfilling and enforcing contracts—a discipline which, while requiring each man to recognize the claims of others, also requires him to maintain his own. In Solon himself this attitude which joins assertion of personal rights with respect for the rights of others was well exemplified; since, when his influence was great he refused to become a despot, though pressed to do so, and in his latter days he resisted at the risk of death the establishment of a despotism. In various ways, then, increasing industrial activity tended to widen the original oligarchic form, and initiate a more popular form. And though these effects of industrialism, joined with subsequently-accumulated effects, were for a long time held in check by the usurping Peisistratidæ, yet, being ready to show themselves when, some time after the expulsion of these tyrants, there came the Kleisthenian revolution, they were doubtless instrumental in then initiating the popular form of government.

Though not in so great a degree, yet in some degree, the same causes operated in liberalizing and widening the Roman oligarchy. Rome "was indebted for the commencement of its importance to international commerce"; and, as Mommsen points out, "the distinction between Rome and the mass of the other Latin towns must certainly be traced back to its commercial position, and to the type of character produced by that position. . . . Rome was the emporium of the Latin districts." Moreover, as in Athens, though doubtless to a smaller extent, trade brought an increasing settlement of strangers, to whom rights were given, and who, joined with emancipated slaves and with clients, less bound to their patrons, formed an industrial population, the eventual inclusion of which in the burgess-body caused that widening of the constitution effected by Servius Tullius.

The Italian republics of later days again show us, in numerous

cases, this connection between trading activities and a freer form of rule. The Italian towns were industrial centers. "The merchants of Genoa, Pisa, Florence, and Venice supplied Europe with the products of the Mediterranean and of the East; the bankers of Lombardy instructed the world in the mysteries of finance and foreign exchanges; Italian artificers taught the workmen of other countries the highest skill in the manufactures of steel, iron, bronze, silk, glass, porcelain, and jewelry. Italian shops, with their dazzling array of luxuries, excited the admiration and envy of foreigners from less favored lands." Then, on looking into their histories, we find that industrial guilds were the bases of their political organizations; that the upper mercantile classes became the rulers, in some cases excluding the nobles; and that, while external wars and internal feuds tended continually to revive narrower, or more personal, forms of rule, rebellions of the industrial citizens, from time to time occurring, tended to reëstablish popular rule.

When we join with these the like general connections that arose in the Netherlands and in the Hanse towns; when we remember the liberalization of our own political institutions which has gone along with growing industrialism; when we observe that the towns more than the country, and the great industrial centers more than the small ones, have given the impulses to these changes—it becomes unquestionable that, while by increase of militant activities compound headships are narrowed, they are widened in proportion as industrial activities become predominant.

In common with the results reached in preceding chapters, the results above reached show that types of political organization are not matters of deliberate choice. It is common to speak of a society as though it had, once upon a time, decided on the form of government which thereafter existed in it. Even Mr. Grote, in his comparison between the institutions of ancient Greece and those of mediæval Europe (vol. iii, pages 10–12) tacitly implies that conceptions of the advantages or disadvantages of this or that arrangement furnished motives for establishing or maintaining it. But, as gathered together in the foregoing sections, the facts show us that, as with the genesis of simple political headships, so with the genesis of compound political headships, conditions and not intentions determine.

Recognizing the fact that independence of character is a factor, but ascribing this independence of character to the continued existence of a race in a habitat which facilitates evasion of control, we saw that, with such a nature so conditioned, coöperation in war causes the union on equal terms of groups whose heads are joined to form a directive council. And according as the component groups are governed more or less autocratically, the directive council is more or less oligarchic. We have seen that in localities differing so widely as do moun-

tain-regions, marshes or mud-islands, and jungles, men of different races have developed political heads of this compound kind. And, on observing that the localities, otherwise so unlike, are alike as being severally made up of parts difficult of access, we can not question that to this is mainly due the governmental form under which their inhabitants unite.

Besides the compound headships which are thus indigenous in places favoring them, there are other compound headships which arise after the break-up of preceding political organizations. Especially apt are they so to arise where the people, not scattered through a wide district but concentrated in a town, can assemble bodily. Control of every kind having disappeared, it happens in such cases that the aggregate will has free play, and there establishes itself for a time that relatively popular form with which all government begins; but, regularly or irregularly, a superior few become differentiated from the many, and of predominant men some one is made, directly or indirectly, most predominant.

Compound headships habitually become, in course of time, either narrower or wider. They are narrowed by militancy, which tends ever to concentrate directive power in fewer hands, and, if continued, almost certainly changes them into simple headships. Conversely, they are widened by industrialism. This, by gathering together aliens detached from the restraints imposed by patriarchal, feudal, or other such organizations, by increasing the number of those to be coerced in comparison with the number of those who have to coerce them, by placing this larger number in conditions favoring concerted action, by substituting for daily enforced obedience the daily fulfillment of voluntary obligations and daily maintenance of claims, tends ever toward equalization of citizenship.

DEGENERATION.

By Dr. ANDREW WILSON.

IT can not be gainsaid that a survey of the fields of life around us impresses one with the idea that the general tendencies of living nature gravitate toward progression and improvement, and are modeled on lines which, as Von Baer long ago remarked, lead from the general or simple toward the definite special and complex. This much is admitted on all hands, and the ordinary courses of life substantiate the aphorism that progress from low grades and humble ways is the law of the organic universe that hems us in on every side, and of which, indeed, we ourselves form part. The growth of plant-life, which runs concurrently with the changing seasons of the year, impresses this

fact upon us, and the history of animal development but repeats the tale. From seed to seed-leaf, from seed-leaf to stem and leaves, from simple leaves to flower, and from flower to fruit, there is exhibited a natural progress in plant-existence, which testifies eloquently enough, by analogy at least, to the existence of like tendencies in all other forms of life. Similarly, in the animal host, progressive change is seen to convert that which is literally at first "without form and void" into the definite structure of the organism. A minute speck of protoplasm on the surface of the egg—a speck that is indistinguishable, in so far as its matter is concerned, from the *materies* of the animalcule of the pool—is the germ of the bird of the future. Day by day the forces and powers of development weave the protoplasm into cells, and the cells into bone and muscle, sinew and nerve, heart and brain. In due season the form of the higher vertebrate is evolved, and progressive change is once more illustrated before the waiting eyes of life-science. But the full meaning of most problems which life-science presents to view is hardly gained by a merely cursory inspection of what may be called the normal side of things. The by-paths of development—more frequently, perhaps, than its beaten tracks—reveal guiding clews and traces of the manner in which the progress in question has come to pass. So, also, the side-avenues of biology open up new phases of, it may be, the main question at issue, and may reveal, as in the present instance, an interesting reverse to the aspects we at first deem of sole and paramount importance. For example, a casual study of the facts of animal development is well calculated to show that life is not all progress, and that it includes retrogression as well as advance. Physiological history can readily be proved to tend in many cases toward backsliding, instead of reaching forward and upward to higher levels. This latter tendency, beginning now to be better recognized in biology than of late years, can readily be shown to exercise no unimportant influence on the fortunes of animals and plants. In truth, life at large must now be regarded as existing between two great tendencies—the one progressive and advancing, the other retrogressive and degenerating. Such a view of matters may serve to explain many things in living histories which have hitherto been regarded as somewhat occult and difficult of solution; while we may likewise discover that the coexistence of progress and retrogression is a fact perfectly compatible with the lucid opinions and teachings concerning the origin of living things which we owe to the genius of Darwin and his disciples.

A fundamental axiom of modern biology declares that in the development of a living being we may discern a panoramic unfolding, more or less complete, of its descent. "Development repeats descent" is an aphorism which cultured biology has everywhere writ large over its portals. Rejecting this view of what development teaches, the phases through which animals and plants pass in the course of their

progress from the germ to the adult stage present themselves to view as simply meaningless facts and useless freaks and vagaries of Nature. Accepting the idea—favored, one may add, by every circumstance of life-science—much that was before wholly inexplicable becomes plain and readily understood. And the view that a living being's development is really a quick and often abbreviated summary of its evolution and descent both receives support from and gives countenance to the general conclusion that life's forces tend as a rule toward progress, but likewise exhibit retrogression and degeneration. If a living being is found to begin its history, as all animals and plants commence their existence, as a speck of living jelly, comparable to the animalcule of the pool, it is a fair and logical inference that the organisms in question have descended from lowly beings, whose simplicity of structure is repeated in the primitive nature of the germ. If, to quote another illustration, the placid frog of to-day, after passing through its merely protoplasmic stage, appears before us in the likeness of a gill-breathing fish (Fig. 1), the assumption is plain and warrantable that the frog

FIG. 1.—DEVELOPMENT OF FROG.

race has descended from some primitive fish stock, whose likeness is reproduced with greater or less exactness in the tadpoles of the ditches. Or if, to cite yet another example, man and his neighbor quadrupeds (Fig. 2), birds, and reptiles, which never breathe by gills at any period of their existence, are found in an early stage of development to possess "gill-arches" (*g*), such as we naturally expect to see, and such as we find in the fishes themselves, the deduction that these higher animals are descended from gill-bearing or aquatic ancestors admits of

no denial. On any other theory, the existence of gill-arches in the young of an animal which never possesses gills is to be viewed as an inexplicable freak of Nature—a dictum which, it is needless to remark, belongs to an era one might well term prescientific, in comparison with the "sweetness and light" of these latter days.

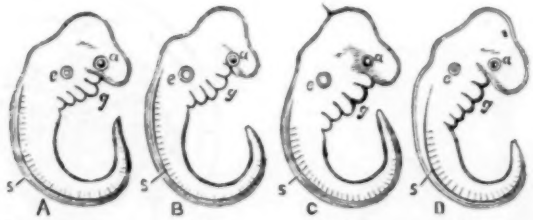


FIG. 2.—PIG. CALF. RABBIT. MAN.

Hanging very closely on the aphorism respecting development and its meaning, is another biological axiom, wellnigh as important as the former. If development teaches that life has been and still is progressive in its ways, and that the simpler stages in an animal's history represent the conditions of its earliest ancestors, it is a no less stable proposition that at all stages of their growth living beings are subject to the action of outward and inward forces. Every living organism lives under the sway and dominance of forces acting upon it from without, and which it is enabled to modify and to utilize by its own inherent capabilities of action. It is, in fact, the old problem of the living being and its surroundings applied to the newer conceptions of life and nature which modern biology has revealed. The living thing is not a stable unit in its universe, however wide or narrow that sphere may be. On the contrary, it exists in a condition of continual war, if one may so put it, between its own innate powers of life and action, of living and being, and the physical powers and conditions outside. This much is now accepted by all scientists. Differences of opinion certainly exist as to the share which the internal constitution of the living being plays in the drama of life and progress. It seems, however, most reasonable to conclude that two parties exist to this, as to every other bargain; and, regarding the animal or plant as plastic in its nature, we may assume such plasticity to be modified on the one hand by outside forces, and on the other by internal actions proper to the organism as a living thing. Examples of such tendencies of life are freely scattered everywhere in Nature's domain. For instance, we know of many organisms which have continued from the remotest ages to the present time, without manifest change of form or life, and which appear before us to-day the living counterparts of their fossilized representatives of the chalk, or it may be of Silurian or Cambrian times. The lamp-shells (*Terebratula*) of the chalk exist in our own seas with wellnigh inappreciable differences. The *Lingula*

or *Lingulella* (Fig. 3, *a*), another genus of these animals, has persisted from the Cambrian age (*b*, *c*) to our own times, presenting little or no change for the attention of the geological chronicler. The curious king-crabs, or *Limuli* (Fig. 4), of the West Indies are likewise pre-

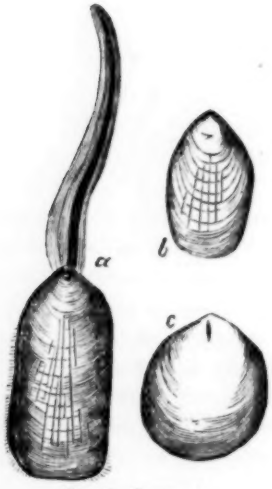


FIG. 3.—LINGULA.

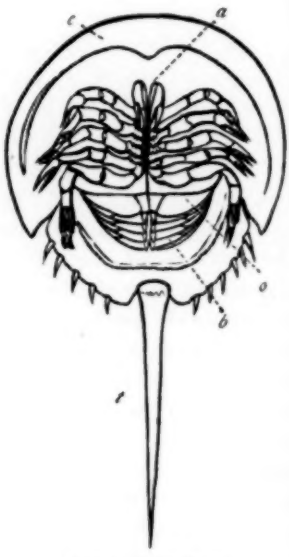


FIG. 4.—KING CRAB.

sented to our view, with little or no variation, from very early ages of cosmical history; and of the pearly nautilus (Fig. 8)—now remaining as the only existing four-gilled and externally shelled cuttle-fish—the same remark holds good. The fishes, likewise, are not without their parallel instances of lack of change and alteration throughout long ages of time. The well-known case of the genus *Beryx* presents us with a fish of high organization, found living in the Atlantic and Pacific Oceans, and which possesses fossil representatives and *fac-similes* in the chalk (Fig. 5.) From the latter period to the present day, the genus *Beryx* has therefore undergone little modification or change. The same remark certainly holds good of many of those huge "dragons of the prime" (Figs. 6 and 7), which reveled in the seas of the Trias, Oölite, and Chalk epochs—developed in immense numbers in these eras of earth's history, but disappearing for ever from the lists of living

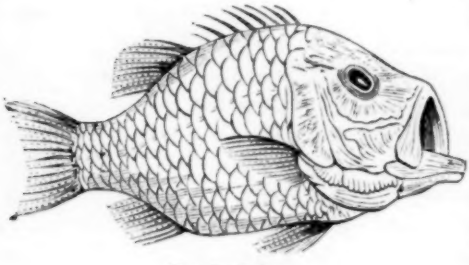


FIG. 5.—BERYX.

things at the close of the Cretaceous age, and exhibiting little or no change during their relatively brief history.

Such cases of stability amid conditions which might well have favored change, and which saw copious modification and progression in other groups of animals, might at first sight be regarded as presenting a serious obstacle to the doctrine of progressive development on which the whole theory of evolution depends. As such an obstacle, the series of facts in question was long regarded; as such, these facts are sometimes even now advanced, but only by those who imperfectly appreciate and only partially understand what the doctrine of evolution teaches and what its leading idea includes. Even Cuvier himself, when advancing the case of the apparently unchanged mummies of Egyptian animals against Lamarck's doctrine of descent, failed—possibly through the imperfectly discussed stage in which the whole question rested in his day—to understand that the very facts of preservation revealed in the monuments of Egypt testified to the absence of those physical changes which could alone have affected the animals of the Nile land. But the fuller consideration of that theory of nature which credits progressive change as the usual way of life, shows us that it is no part of evolution to maintain either that living beings must needs undergo continual change, or that they must change and modify at the same rate. On the contrary, Mr. Darwin, in his classic work, maintains exactly the opposite proposition. There are, in fact, two great factors at work in living nature—a tendency to vary and change, and the influence of environments or surroundings. Given the first tendency, which is not at all a matter of dispute, the influence of the second is plainly enough discernible in bringing to the front either the original,

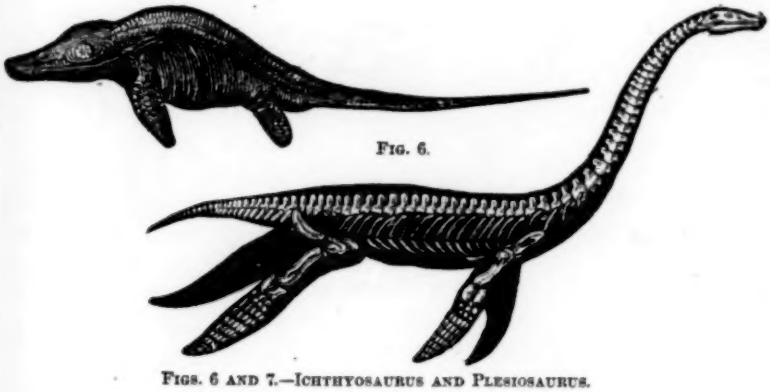


FIG. 6.

FIGS. 6 AND 7.—ICHTHYOSAURUS AND PLESIOSAURUS.

primitive, or, as it might be named, the parent form, or the varying forms which are produced by modification of the parent. As it has well been put: "Granting the existence of the tendency to the production of variations, then, whether the variations which are produced

shall survive and supplant the parent, or whether the parent form shall survive and supplant the variations, is a matter which depends entirely on those conditions which give rise to the struggle for existence. If the surrounding conditions are such that the parent form is more competent to deal with them and flourish in them than the derived forms, then in the struggle for existence the parent form will maintain itself, and the derived forms will be exterminated. But, if, on the contrary, the conditions are such as to be more favorable to a derived than to the parent form, the parent form will be extirpated, and the derived form will take its place. In the first case, there will be no progression, no change of structure, through any imaginable series of ages; in the second place, there will be modification and change of form." To the same end Darwin himself leads us. In one or two very pregnant passages, the author of the "Theory of Natural Selection" very plainly indicates why progression should not be universal, and why certain beings remain lowly organized while others attain to the summit and pinnacle of their respective organizations. "How is it," says Darwin, "that throughout the world a multitude of the lowest forms still exist? and how is it that in each great class some forms are far more highly developed than others? Why have not the more highly developed forms everywhere supplanted and exterminated the lower?" Answering his own queries, Darwin says that natural selection by no

FIG. 8.—PEARLY NAUTILUS.

means includes "progressive development—it only takes advantage," he remarks, "of such variations as arise and are beneficial to each creature under its complex relations of life. And it may be asked, what advantage, as far as we can see, would it be to an infusorian animalcule—to an intestinal worm—or even to an earthworm, to be highly organized? If it were no advantage, these forms would be

left, by natural selection, unimproved or but little improved, and might remain for ages in their present lowly condition. And geology tells us that some of the lowest forms, as the foraminifera (Fig. 9), infusoria, and rhizopods, have remained for an enormous period in nearly their present state. But," adds Darwin, with a characteristically impartial view of matters, "to suppose that most of the many now existing low forms have not in the least advanced since the first dawn of life would be extremely rash ; for every naturalist who has dissected some of the beings now ranked as very low in the scale must have been struck with their really wondrous and beautiful organization."

Thus one of the plainest facts of natural history, namely, that in even one group or class of animals we find forms of exceedingly low structure included along with animals of high organization — the apparently diverse bodies being really modeled on the one and the same type—is explained by the consideration that with different conditions, or with various conditions acting differently upon unlike constitutions, we expect to find extreme differences in the rank to which the members of a class may attain. In the class of fishes we find the worm-like, clear-bodied lancelet of an inch long associated with the ferocious shark, the active dogfish, or the agile food-fishes of our table. But, as Darwin remarks, the shark would not tend to supplant the lancelet, their spheres and their conditions of existence being of diverse nature. The same remark applies to many other classes of living beings. So that lowly beings still live as such among us, and preserve the primitive simplicity of their race, firstly, because the conditions of life and their limited numbers may not have induced any great competition or struggle for existence. On the "let-well-alone" principle we may understand why some animals, such as the lancelet itself, have lagged behind in the race after progress. Then, secondly, as Darwin remarks, favorable variations, by way of beginning the work of progress, may never have appeared—a result due, probably, as much to hidden causes within the living being as to outside conditions. We may not fail to note, lastly, that the simpler and more uniform these latter conditions are—as represented in the abysses of the ocean, for example—the less

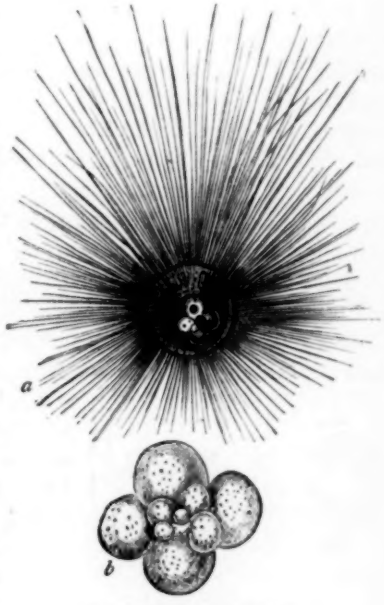


FIG. 9.—GLOBIGERINA, ETC.

incentive is there for the progress and evolution of the races which dwell in their midst.

This somewhat lengthy introduction to the subject of degeneration and its results is in its way necessary for the full appreciation of the fashion in which degeneration relates itself to the other conditions of life. From the preceding reflections it becomes clear that three possibilities of life await each living being. Either it remains primitive and unchanged, or it progresses toward a higher type, or, last of all, it backslides and retrogresses. As the first condition, that of stability, is, as already noted, perfectly consistent with the doctrine of descent, so are the two latter conditions part and parcel of that theory. The stable state forces the animal to remain as it now is, or as it has been in all times past; the progressive tendency will make it a more elaborate animal; and the progress of degeneration will, on the other hand, tend to simplify its structure. It requires no thought to perceive that progress is a great fact of nature. The development of every animal and plant shows the possibilities of nature in this direction. But the bearings of degeneration and physiological backsliding are not, perchance, so clearly seen; hence, to this latter aspect of biology we may now specially direct our attention.

That certain animals degenerate or retrogress in their development before our eyes to-day, is a statement susceptible of ready and familiar illustration. No better illustrations of this statement can be found than those derived from the domain of parasitic existence. When an animal or plant attaches itself partly or wholly to another living being, and becomes more or less dependent upon the latter for support and nourishment, it exhibits, as a rule, retrogression and degeneration. The parasitic "guest" dependent on its "host" for lodging alone, or it may be for both board and lodging, is in a fair way to become degraded in structure, and, as a rule, exhibits degradation of a marked kind, where the association has persisted sufficiently long. Parasitism and servile dependence act very much in structural lower life as analogous instances of mental dependence on others act in ourselves. The destruction of characteristic individuality and the extinction of personality are natural results of that form of association wherein one form becomes absolutely dependent on another for all the conditions of life. A life of attachment exhibits similar results, and organs of movement disappear by the law of disuse. A digestive system is a superfluity

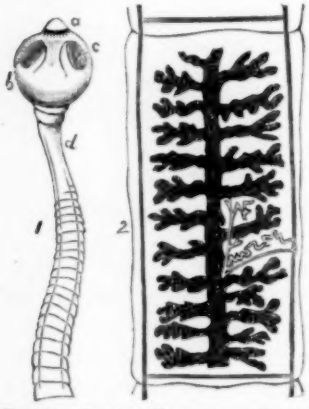


FIG. 10.—COMMON TAPEWORM (*Tænia solium*). 1. The head extremity, magnified, showing hooks (*a*), and suckers (*b*, *c*); *d*, neck, with immature joints. 2. A joint, largely magnified, showing the branching "ovary," in which the numerous eggs of each joint are matured.

to an animal which, like a tapeworm (Fig. 10), obtains its food ready-made in the very kitchen, so to speak, of its host. Hence the lack of a digestive apparatus follows the finding of a free commissariat by the parasite. Organs of sense are not necessary for an attached and rooted animal; these latter, therefore, go by the board, and the nervous system itself becomes modified and altered. Degradation, wholesale and complete, is the penalty the parasite has to pay for its free board and lodging; and in this fashion Nature may be said to revenge the host for the pains and troubles wherewith, like the just of old, he may be tormented. Numerous life-histories testify clearly enough to the correctness of the foregoing observations. Take, as an example, the history of *Sacculina* (Fig. 11, A), which exists as a bag-like growth attached to the bodies of hermit-crabs, and sends root-like processes into the liver of its host. No sign of life exists in a

A B

FIG. 11.—SACCULINA AND YOUNG.

sacculina beyond mere pulsation of the sac-like body, into and from which water flows by an aperture. Lay open this sac, and we shall find the animal to be a bag of eggs and nothing more. But trace the development of a single egg, and one may derive therefrom lessons concerning living beings at large, and open out issues which spread and extend far afield from sacculina and its kin. Each egg of the sac-like organism develops into a little active creature, possessing three pairs of legs, generally a single eye, but exhibiting no mouth or digestive system—parasitism having affected the larva as well as the adult. Sooner or later, this larva—known as the *nauplius* (B)—will develop a kind of bivalve shell; the two hinder pairs of limbs are cast off and replaced by six pairs of short swimming-feet; while the front pair of limbs develops to form two elongated organs whereby the young sacculina will shortly attach itself to a crab "host." When the latter event happens, the six pairs of swimming-feet are cast off, the body assumes its sac-like appearance, and the sacculina sinks into its adult stage—a pure example of degradation by habit, use, and wont. So also with certain near neighbors of these crab-parasites, such as the *Lerneans*, which adhere to the gills of fishes. Beginning life as a three-legged "nauplius," the lernean retrogresses and de-

generates to become a mere elongated worm, devoted to the production of eggs, and exhibiting but little advance on the sacculina. There are dozens of low crustaceans which, like sacculina, afford examples of animals which are free and locomotive in the days of their youth, but which, losing eyes, legs, digestive system, and all the ordinary belongings of animal life, "go to the bad," as a natural result of participating in what has been well named "the vicious cycle of parasitism."

Plainly marked as are the foregoing cases, there are yet other familiar crustaceans which, although not parasites, as a rule, nevertheless illustrate animal retrogression in an excellent manner. Such are the sea-acorns (*Balani*), which stud the rocks by thousands at low-water mark, and such are the barnacles (Fig. 12), that adhere to floating timber and the sides of ships. In the development of sea-acorns and barnacles, the first stage is essentially like that of the sacculina. The young barnacle is a "nauplius," three-legged, free-swimming, single-eyed, and possessing a mouth and digestive apparatus. In the next stage we again meet with the six pairs of swimming-feet seen in sacculina, with the enormously developed front pair of legs serving as "feelers," and with two "magnificent compound eyes," as Darwin describes the organs of vision. The mouth in this second stage, however, is closed, and feeding is therefore impossible. As Darwin remarks, the function of the young barnacles "at this stage is to search out by their well-developed organs of sense and to reach by their active powers of swimming a proper place on which to become attached, and to undergo their final metamorphosis. When this is completed," adds Darwin, "they are fixed for life; their legs are now converted into prehensile organs; they again obtain a well-constructed mouth, but they have no antennæ, and their two eyes are now reconverted into a minute, single, simple eye-spot." A barnacle is thus simply a highly modified crab-like animal which fixes itself by its head to the floating log, and which "kicks its food into its mouth with its feet," to use the simile and description of biological authority. The development of its "shell" and stalk are matters which do not in the least concern its place in the animal series. These latter are local and personal features of the barnacle tribe. For in the "sea-acorns,"

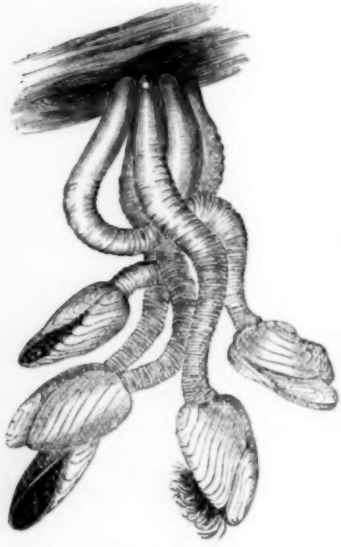


FIG. 12.—BARNACLES.

which pass through an essentially similar development, there is no stalk; and the animal, after its free-swimming stage, simply glues its head, by a kind of marine cement of its own manufacture, to the rock, develops its conical shell, and like the barnacle uses its modified feet as means for exercising the commissariat and nutritive function. It is true that in some respects the adult barnacle may be regarded as lower than the young, and therefore as a degenerate being. Thus, it is lower when eyes, feelers, and movements are taken into account. In other respects the adult may be considered of higher organization than the larva. These higher traits we may logically enough suppose represent the special advances which adult barnacle-life has made on its own account. But, on the whole, degradation and retrogression, if not so fully exemplified as in the sacculina, is still plainly enough illustrated in barnacle history. When we further reflect that even such high crustaceans as prawns and allied forms begin life each as a "nauplius" or under an allied guise, we not only merely discover the common origin of all crustaceans in some form represented by the "nauplius" of to-day, but we also witness the possibilities of development which have placed shrimps, prawns, etc., in the foremost rank of the class, and which, conversely, have left the barnacles and sacculinas, through the action of degenerative changes, among the groundlings of the group.

The assumption of a sedentary life, whether parasitic in nature like that of sacculina, or whether it is represented by mere attachment and fixation to some inorganic thing, as in the case of the barnacles, is therefore seen to operate in the direction of producing degeneration of the animal's constitution. The tendency of such habit is toward simplification of structure and not toward that progressive advance and evolution which, in the case of the higher crustacean races, have evolved from the relatively simple "nauplius" of the past the crabs, lobsters, shrimps, and prawns of to-day.—*Gentleman's Magazine.*

[*To be continued.*]

THE PRIMEVAL AMERICAN CONTINENT.

By L. P. GRATACAP, A.M.

THE reader may recall standing, when a child, by the side of a toy-dam in the course of some little stream, and, were a breach made in the mimic masonry, remember the mute interest with which he watched the slow emergence of fairy islands as points of rock and shoals of mud slowly appeared above the water's surface—how the detached summits, at first round spots, assumed varied outlines indented with cones or bristling with promontories; how they multiplied as the ebbing water exposed newer and lower levels, until the

tiny sea was dotted with an archipelago of islands, whose nearing shores, gradually joining, formed chains of islets; how the inclosed area of water contracted, and, in the union of all their separate figures, vanished. The wet surfaces, broken by depressions, were marked by pits of water from whose sides stole along intermediate creases, thread-like lines of water, the river system of the miniature continent, its sinuous shores impressed by the ripples of a mimic sea. The recollection of boyish pleasures becomes touched with a deeper interest when one is taught to recognize in this the picture of what in a larger way, and under cosmic conditions, has happened in the life-history of our own sphere, and to realize that his childish hand may have reproduced at will a somewhat exact copy of the stages of the world's growth.

Suppose this little world so briefly made had been left till the bright sunshine had dried its surface, in some places parched and cracked it, in others evoked a luxuriant growth of grass and flowers, filled its shores with gliding snails and its level mead with teeming ant-hills. Once more the running stream is stopped, and slowly the muddy tide rises higher and higher, obliterates the lowlands and creeps slowly up the sides of the high ground, around the skirts of its pygmy mountain-chains, and rolls restored amid groups of remade islets. Under the guidance of this retrospective knowledge let the current be arrested to permit some portions of that first-made land to remain uncovered. With favorable conditions, as a stream carrying abundance of fine silt, the water moving sluggishly over the inundated surfaces will drop its earthy burden upon them in thin, loose layers, evenly at first, but, as shallows are formed, irregularly modified, or as sudden freshets produce stronger currents, eddies and ripple-bars gather or disturb the sediment. New lands in wet banks and knobs will begin to appear over the highest ridges. Break away again the barrier, and cause the water to recede, exposing in a similar succession of phases the bared surface. The expectant eye now notices certain changes: old landmarks are removed from sight, valleys have been converted into plains, new hills have arisen, lakes are seen here and there where before was dry land, new contour lines surround the structural ridges which yet remain, modified indeed, but distinctly recognizable, while the low verdure of grass and the numerous pinnacles of ant-hills have together disappeared beneath a universal blanket of mud. Only upon the very highest points do the scattered remnants of the first surface appear unchanged, because they alone were exempted from general flood. Again the sun shines upon it, new seeds sprout, other insects flourish, and fresh showers fall. In spots the old land is exposed; the new having been washed away from it; it may be easily recognized by its fauna and flora, the drowned ants, and the hidden grass.

Again and again, under varying conditions, may our experimental

world be sunk and raised, preserving, possibly, through all the changes the rudimentary outlines of hills and valleys by which it was first characterized and marked. And imagining that every new stratum was ingeniously varied in the color and to some extent in the nature of its mineral constituents, and that, upon each reappearance of this diminutive continent, the skillful experimentalist spread a new form of life, what at last might be, after some exposure to weathering and change, the character of its surface? Evidently something like this: in the first place, since, in consequence partly of denudation and partly of only partial submergence, certain tracts will appear cleared of the later deposits, we will find numbers of the whole series laid bare in spots from the highest point, where, as presupposed, only the primitive layer is seen, to the outskirts of the island where the latest layer forms the surface; or to interior depressions, where lake-like centers existed alternately filled and emptied with each recurring deluge. Endless diversity might be introduced into such a scheme, so far as local detail is concerned, but under the conditions given the island would exhibit lines of stratification, each distinguished by color or *fossils*, and following each other in the order instituted by the youthful world-makers. Along the crevices and tiny gullies we might detect the minute succession of various strata, and at intervals fragments of the buried life would be revealed. Enlarge this minute illustration till it assumes continental dimensions, reverse the periodic inundations from the water rising to periodic inundations from the land sinking, and in a rude way, subject to important modifications, the reader will be prepared to realize the formative system developed in the construction of our northern hemisphere.

Through a sequence of phases, somewhat distinctively bounded by periods of depression and consequent submergence, and periods of elevation and consequent drainage, land was added to an initial nucleus by enormous marine accumulations, the *débris* of animal organisms, and the detritus from terrestrial abrasion. Chemical action, heat, and molecular transference hardened these layers into stone, and thus the new-made land, though undergoing change from recurring submergence, and through subaërial denudation, yet, to a great extent, resisted removal while it contributed to the growth of the incipient continent, and formed the ground upon which new-laid strata were heaped.

In the American Museum of Natural History, seven maps, the work of Professor R. P. Whitfield, have recently been added to the Geological Cabinet, intended to exhibit the growth of the eastern half of the North American Continent from 95° west longitude eastward to its shores. The scheme of their arrangement is the exhibition, by contrasted colors, of the superficial areas where to-day the rocks of the various geological epochs are exposed, beginning with the oldest and rising to the youngest, whereby we seem to seize at critical points the

stages of the continent's enlargement, and follow with the eye the stupendous changes which shaped it.

The first chart presents in its colored parts the primeval territory, which geologists regard as the first-made land of our continent, the archaic regions, around whose rocky framework were gathered the accretions of succeeding ages. It is the azoic *terrain*, that composite foundation of gneiss, granite, schists, crystalline limestones, sandstones, serpentine, and iron-ore masses, which defined the geological architecture of America. In its isolated ridges, cleared of the later and adjacent strata, we have before our eyes the principal portions of a continent upon which the ancient oceans played

". . . their priest-like task
Of pure ablution round earth's *lifeless* shores."

Its sterile stretches unalleviated by a mantle of waving woods, unanimated by moving figures, reflected the harsh sunshine from rugged terraces or monotonous lowlands, a cheerless waste bathed by pre-adamite seas.

Starting from a point near Montgomery, in Alabama, the archæan country stretches northeasterly along the Appalachian axis and, rapidly widening, incloses large districts in Georgia, western South and North Carolina, of which latter State it defines the western boundary, and reaches eastward nearly to Raleigh. Passing on both sides of a lenticular area lying in North Carolina and Virginia, it narrows to a strip west of Richmond, where it is deeply bitten by a round gulf, and pressed to the seaboard, forms a thin isthmus west of Washington, then expands at Baltimore, and, lobed out into a pennant-shaped appendage, reaches down toward Newcastle, Delaware. From a little west of Burlington, nearly to Easton, a white patch shows an area where the archean rock is no longer seen, but at the latter point a thin strip follows the Appalachian uplift and, including the highlands of West Point, appears as an attenuated finger or arm of a great area, which pushes south as far as Manhattan Island, whose gneissoid rocks compose it, and eastward over the western half of Connecticut. In Massachusetts the archæan rocks bifurcate ; a finger reaches to the northern boundary of the State, where a thin connection exists with the great eastern region, and a shrunken area extends northward through the Berkshire Hills. The western limit of this latter strip lies some ten or fifteen miles from the eastern boundary of New York, and, entering Vermont at its southeastern border, widens out till, at Montpelier, almost half the State is covered. Slowly broadening thence, we follow its outlines into Canada, approach the St. Lawrence, and then, with an abrupt eastward deflection, trace it in a sinuous tongue until it touches the river at Mount Camille. The large eastern seaboard area of archæan rocks commences at Saybrook, on Long Island Sound, whence northward, limited by a sweeping curve, it covers the eastern part of

Connecticut, almost all of Rhode Island, and eastern Massachusetts, with some slight exceptions, where islands of later rock occur, as southwest from Boston and about Lowell. Nearly all New Hampshire is covered by it, and in Canada it forms another strip parallel to the first, while eastward it constitutes the surface rock of much of Maine, wherein, at last, it breaks up into scattered patches, lying like Titanic stepping-stones, from Augusta northward to the desolate horn of Newfoundland. One of these districts surrounds Mount Katahdin; another, in a long, easterly-deflected strip of land, runs from Mount Desert northward to Chaleur Bay, New Brunswick; while from Machias Bay a third streams northward in a narrow ribbon.

Separated areas are found along the southern shore of Newfoundland and upon Cape Breton Island.

In the United States four other extensive archæan territories exist east of 95° west longitude; one in the Adirondack region, embracing the immense northern park of New York as far north as Malone, and stretching southward almost to Saratoga Springs, bordered by the State line, and, linking, through a narrow aperture between surfaces of subsequent strata, with the enormous reaches of azoic land which form Quebec and Ontario Provinces, it merges into two lateral expansions, on one side into the limitless highlands of Labrador, on the other into the ridges, valleys, and plateaus of the lake country northward to the Arctic Circle.

The second area is in northern Wisconsin and Michigan, embracing the Marquette region, famous for its ores. The third is a neighboring and related province in eastern Minnesota, from the South Bend on the Minnesota River, widening northward and uniting with the Canadian area about the Rainy Lake region. The fourth, a diminutive outlier, comprises the Iron Mountain and Pilot Knob country in southeast Missouri.

These large spaces of archæan rock represent the floor-layers, as now exposed in the eastern United States, of the continent's superstructure. In these parts of our country they form the surface-rock, and whether they have been always raised beyond the reach of sedimentary deposit or have been scoured and relieved by frost and flood of superincumbent strata, whether their present extent is conterminous with their limits, as once revealed above the level of primeval seas, or whether shrunken by subsidence and partially obliterated by later formations, they are at any rate outcrops of the vast bedding on which ocean and continent alike repose. But when we examine these aged stones we find that they themselves appear as the cemented residues and stratified deposits formed from some yet preëxistent firmament of land. In serial bands, conforming to each other, as book lies against book, we find limestone, slates, sandstones, quartzites, schists, and gneiss, and we know now that these regular layers, hard, distinct, and characterized by color, constituents, and adventitious minerals, were

once water-drifted beds *metamorphosed*, transfigured, as it were, by heat and pressure into this adamantine pavement; and, further, we find that they must have been so formed in the attrition and decay of yet older continents. The dim perspective opens backward to the very verge of chaos.

After deposition, and in a somewhat consolidated state, they were slowly raised, their emergence above the water accompanied a contraction of the earth's crust, and the flexible series, from top to bottom, folded up in deep and multiplied plications. Mountain-chains arose, their strata tilted up, contorted and complicated in related groups of synclinal and anticlinal axes, and, by the effective agency of heat and aqueous distillation through the myriad pores of the rock, a mineralogical change ensued. The argillaceous muds were hardened into slates and schists, the calcareous shoals became crystalline limestones, marbles, and dolomites, the siliceous bands became quartzites and sandstones, the iron slime crystallized into colossal sheets of iron-ore, magnesian sediments became serpentine, and through all there developed beautiful minerals under various associations and marking different horizons in this complex pile of natural masonry. Feldspars, pyroxene, mica, apatite, chondrodite, epidote, and garnet are a few of many which, in crevice and seam, and scattered through the matrix rock, remain as token, and possibly revelation, of the changes here enacted. From this archæan country come the magnetic oxide of the Adirondacks, the hematite of Marquette, the soft lead of Ticonderoga, the dolomite of Westchester County, the mica of North Carolina, the syenites and granites of Maine, the marbles of Vermont, the tinstone of New Hampshire, and the phosphates of Canada. Over thirty thousand feet in vertical thickness is the estimated depth of this gigantic mass —fitting foundation for the arches of the world.

Recent study, notably that of Dr. T. Sterry Hunt, separates this wonderful epoch into four secondary ones of unequal duration and varying character. First, the Laurentian, a name given by the Geological Survey of Canada and applied originally to the rocks of the Laurentian highlands, those abraded swells of land which overlook the St. Lawrence and rise in rugged grandeur four thousand feet high above the shadowed waters of the Saguenay. This primitive tract of archæan territory embraces the Adirondacks of New York, the region about Ottawa, portions of Newfoundland, and probably includes the rock assigned to this age in Massachusetts, Connecticut, and Rhode Island, and the long back which makes up the Highlands of the Hudson, the South Mountain of New Jersey, and the ridges about Richmond and Mount Roan in North Carolina. The rock is "a strong, massive gneiss, reddish or grayish in color."

Following this is the Norian, unconformable with the Laurentian, viz., not fitting into it, as though the latter, first made under water, solidified and raised, had again been depressed and received these sec-

ondary deposits. The Norian rock is distinguished by the abundance of labradorite, a feldspar possessing iridescent tints, and is found in Essex County, New York, Labrador, extensively along the St. Lawrence, upon Lake Huron, while "bowlders of it are occasionally found along the eastern shores of Maine and Massachusetts, and also in northern New Jersey."

The Huronian era succeeds, and is a name applied to the upper layers of the Huron Mountains, Lake Superior, to the Green Mountain series, and to detached areas along the coast of Newfoundland, eastern New England, and southward upon the flanks of the Blue Ridge. The Mont Alban series marks the fourth period, so named after the White Mountain layers in New Hampshire, where the aggregated display of crystalline schist is assigned to this province. New York, Philadelphia, Baltimore, and Washington occupy this *terrain*, and these rocks occur throughout the Blue Ridge, as far as Georgia, of more than passing significance, as they form the gold-bearing strata in Virginia, North and South Carolina. In these rocks the garnet, staurolite, cyanite, and chiastolite, favorites of the mineralogist, are almost exclusively found.

Instinctively we ask: Did no living thing exist through all these ages; did the mechanical wear and tear of rock-masses and their redeposition by mechanical means solely occupy the desolate centuries? The proofs of organic activity, involving the functions of life, are numerous, but the exact character of that life and the special conditions under which it flourished are greatly if not entirely wanting. In the first place, we find in Canada important, indeed inexhaustible deposits of carbon under the form of graphite, and graphite occurs in our coal-measures as the direct product of alteration from coal. These huge masses, distributed in pockets, sheets, and nodules through the archæan rock, indicate the presence of vegetative forces, doubtless exhibited in plants of a low order, but on a scale of tropical exuberance.

These carbon pockets occupy the shrunken areas of what were once vast, waving, and deeply matted beds of algæ, sea-weeds, building up, through innumerable generations amid the gathered detritus of shore and cliff, dense piles of carbonaceous remains. Or else they are attributable to a fertile growth of lichens which spread, possibly with an almost arborescent vigor, over plain and mountain. These organisms are low in the vegetable hierarchy, and along with them may have lived allied families: the microscopic Desmids and Diatoms, whose siliceous tests showered down through the still oceans; beside them the Corallines and Nullipores, forming calcareous fringes and coral-like thickets; the minute Protophytes and the delicate Charæ. Doubtless this age marked the climax of these plants, and, through multiplied species and in vast numbers, they represented one phase of the ever-restless evolution of vital forces.

The great deposits of iron-ore, though affording no direct evidence

in their remains of plant-life, are no less trustworthy proofs of its existence. They are themselves largely the result of vegetation in some form. Dr. Hunt originally explained this connection, illustrating it by identical processes in the world about us. If the reader visits a bog-land in summer, where slowly-running or stagnant water collects in pools, or if he stands upon the edge of a morass or marsh, he will notice angular, iridescent films floating upon the surface. They are thin pellicles of iron oxide, which will soon break up and sink, to be succeeded by fresh "skins," which in turn disappear, building up a growing layer of bog-iron ore beneath the water. The theory is simple. Iron exists under two forms, a soluble or monoxide, and an insoluble or sesquioxide. The latter is widely disseminated through the rocks and soils. The insoluble modification is reduced to the monoxide or soluble state in the presence of finely divided and rotting vegetable matter, or in water charged with vegetable infusions, as emacerated leaves and tissues. Rains and streams carry it away to lowlands and depressions, where it becomes, through contact with the air, again oxidized or rendered insoluble, and is redeposited in streaks and bands. The widespread action of vegetable acids is here concerned. Humic, crenic, apocrenic, and related acids, in conjunction with the reducing power of carbonaceous residues, removed iron oxide from the original rocks, and through the agency of water gathered it—useless as long as it remained scattered in minute particles through vast *terrains*—into enormous masses, the source and maintenance of our industries, thus garnered through these gentle and silent methods. Such has been the growth of the large deposits in the Marquette region, in the Adirondacks, and at Pilot Knob—deposits which under the influence of heat have become changed into the specular ores, the magnetites, and hematites. They point unmistakably to the existence of plants, and no less to their duration over immense periods of years.

The proofs of animal life are less satisfactory, and have been discredited in high scientific writings, or, more accurately, the morphological types of that life have been rejected, leaving the general presumption unquestioned that animal life of some kind prevailed. In the first place, the phosphatic minerals found in the archæan rocks are considered derivative from organic remains, as to-day phosphorus as a phosphate results from animal secretions, though phosphorus is omnipresent in the plant-world, and the ashes of various vegetables yield from eight per cent. to fifty-three per cent. of phosphoric acid, while the annual shipment of flour and wheat from our shores represents thousands of tons of this element. In this respect the evidence does not seem altogether controlling that these archæan phosphates necessarily resulted from animal *débris*. But the argument rests upon surer grounds. In 1865, Logan, Dawson, Carpenter, and Hunt, prepared a paper of great merit upon an archæan fossil, which they named *Eozoön*, and which they considered representative of the zoölogical sub-king-

dom of the Protozoa and allied to Foraminifera. They represent it as an organism attaching itself by a gelatinous body to sea-floors, enveloping itself with a crust of carbonate of lime in which very small tubes penetrated to the surface through which the sarcodous material within projected in tapering fingers, to be withdrawn at the will of the animal; upon this another layer of protoplastic matter, formed in the growth of the creature, connected with the first, but separated throughout most of its extent by an interlamination of limestone, in which radiating canals are discerned, and which succeeds the earlier poriferous shell. Upon this new calcareous crusts arise, and thus a cellular and tuberiferous mound is formed, compacted and regular, along the base of attachment, but loose, granulated, and divergent at its summit.

In our present seas closely related organisms appear, the Rhizopods, minute bodies, structureless, mere pellets of protoplasm, yet possessed of a secretive function which incases them in exquisitely symmetrical houses of lime. They are naturally low in the animal scale, indeed primary, and the Eozoön seems to have been a Titan progenitor of these hosts of later protozoans whose numberless fragments form the chalk-beds of England and France.

The *Eozoön Canadense* is found in the Laurentian rocks of Canada, other species in the Huronian of Bavaria, and specimens have been described from the Adirondacks and from Massachusetts. Forms strikingly resembling Eozoön may be found in the serpentine ledge in Fifty-ninth Street, near Tenth Avenue, New York. The soft parts in the calcareous skeleton of this Rhizopod have been replaced by minerals, and on the resemblance, amounting almost to identity, between the Eozoön and certain mineral pseudomorphs are based the objections made to its acceptance as of organic origin. King and Rowney, of Dublin, and Möbius, of Germany, have very vigorously attacked it, and lately Roemer rejects it from the list of palæozoic fossils. But it seems impossible to doubt the reality of its animal arrangement. Professor Hitchcock thoughtfully observes in this connection as regards its resemblance to mineral replacements, "Inasmuch as these structures represent the higher efforts of the mineral kingdom in crystallization and the nearest approach to the inorganic world allowed by animal forms, it is not strange that the two extremes should resemble each other sufficiently to deceive practical observers."

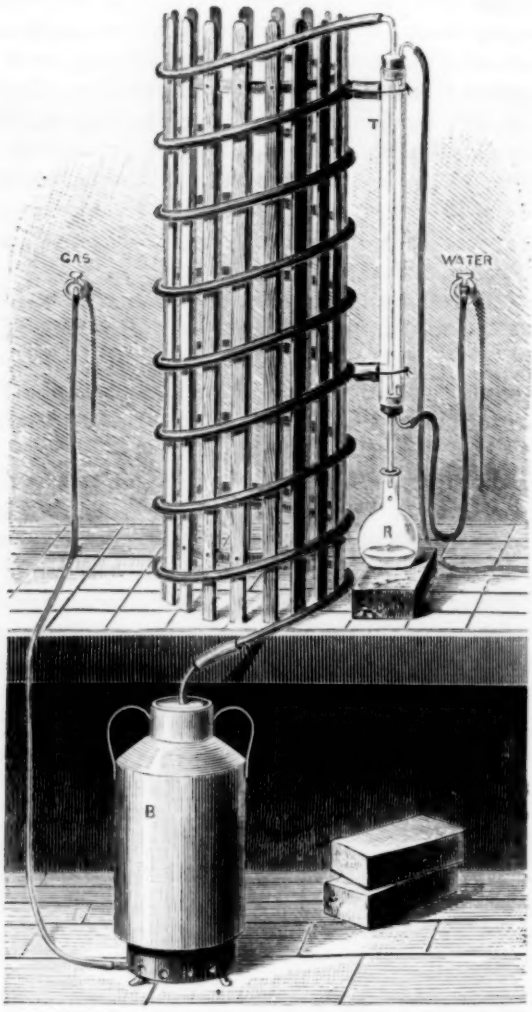
This was, in a few words, the archæan Continent. Its greatest area was in the north, with scattered islands and thin prolongations southward along the present axes of elevation. Subsequent periods built out from this and filled in the shadowy but prophetic sketch of North America—not an azoic or lifeless country, as once thought, yet a territory where silence reigned, broken only by the roar of the surf along its bleak margins, the whistle of the gale through its defiles, and the thunder of tempests upon its plains. "Lonely, silent, and impassive, heedless of man, season, or time, the weight of the Infinite seemed to brood over it."

NATURAL PRODUCTION OF ALCOHOL.*

By GASTON TISSANDIER.

M. A. MÜNTZ, of the French National Agronomical Institute, announces that he has discovered traces of alcohol as a natural product in cultivated soil, rain-water, sea- and river-water, and the atmosphere. He has detected the product, it is true, only in the most

FIG. 1.



infinitesimal quantities, but he has established the fact of its existence by analyses which are at once simple, clear, and convincing.

* Translated from "La Nature."

He has submitted to distillation some fifteen or twenty litres, or quarts, of snow-, rain-, or sea-water in the apparatus which is represented in Fig. 1. This apparatus consists of a milk-can, B, which is made to serve as a boiler, in which the liquid to be distilled is put. The vapors disengaged by the heat pass through a worm about thirty feet long, in which they are resolved; thence through a tube incased in a refrigerating envelope, T, which is kept constantly cool by a current of cold water; and are then condensed in the glass receiver, R. The operation is arrested as soon as one hundred or one hundred and fifty cubic centimetres of liquid—which will contain all the alcohol—have been condensed. The resultant liquid is again distilled in an

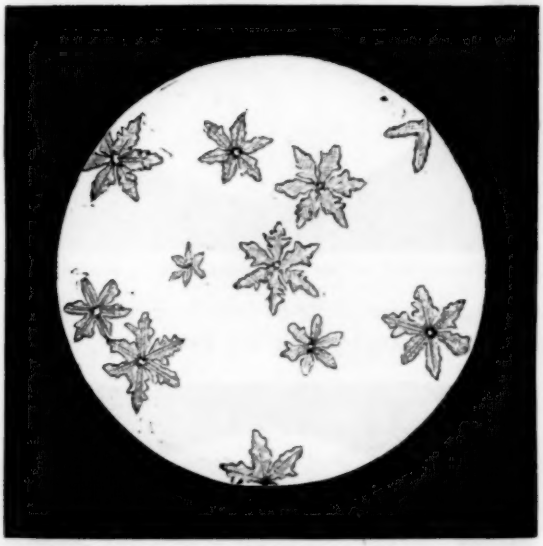


FIG. 2.—CRYSTALS OF IODOFORM OBTAINED BY SYNTHESIS (greatly magnified).

apparatus similar to the former one, but smaller. The latter operation is arrested when some five or six cubic centimetres of liquid have been condensed in a closed receiving-tube, which takes the place of the receiver R in the former apparatus. The tube is then taken away, and to its contents are added a little iodine and carbonate of soda; on heating it slightly, small crystals are precipitated of iodoform, a substance which could not be produced unless alcohol were present. M. Müntz has verified the results of this process by other test experiments. When distilled water, chemically pure, was heated in the same apparatus, the addition of iodine and carbonate of soda was not followed by any reaction. A second verification was obtained by distilling fifteen litres of pure water, to which one millionth part of alcohol had been added; the addition of iodine and carbonate of soda caused a precipitation of iodoform precisely like that which was ob-

tained in treating the natural waters. One or two hundred grammes (three and a half to seven ounces) of tilled earth mixed with a pint of

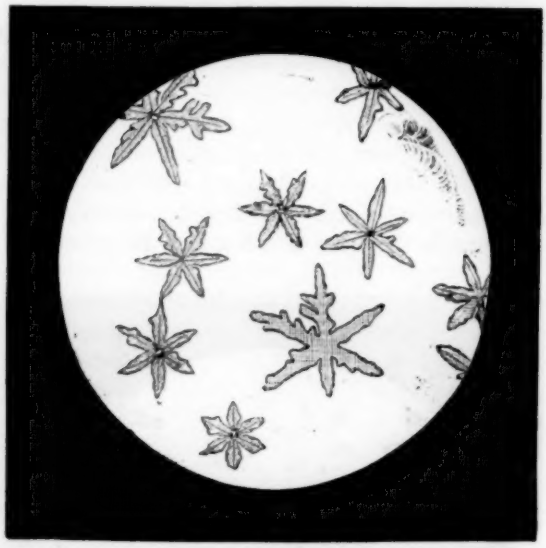


FIG. 3.—CRYSTALS OF IODOFORM OBTAINED WITH RAIN-WATER.

water gave a similar precipitate of iodoform when distilled and exposed to the reactions employed in the other experiments. The pre-

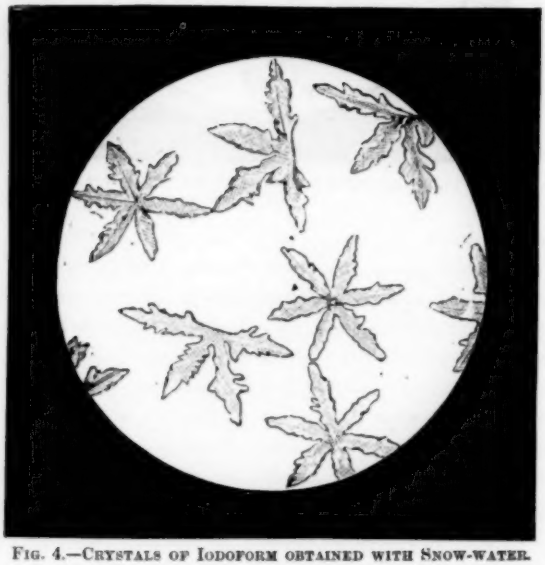


FIG. 4.—CRYSTALS OF IODOFORM OBTAINED WITH SNOW-WATER.

cipitation of iodoform by the addition of iodine and carbonate of soda is a very evident test of the presence of alcohol. Iodoform

has marked characteristics which permit it to be distinguished very readily: the form of its crystals, particularly, is typical; it is of a light yellowish color, and appears under the microscope in the form of six-rayed stars derived from an hexagonal prism, of precisely the form of snow-crystals. The accompanying figures give photographic representations of the crystals as they appear under the microscope. Fig. 2 represents the crystals from pure water to which alcohol has been added in the proportion of one millionth; Fig. 3, those obtained from rain-water; Fig. 4, crystals from snow-water; and Fig. 5, those procured from cultivated soil. M. Müntz's first experiments were made about four years ago. He has since examined a

FIG. 5.—CRYSTALS OF IODOFORM OBTAINED WITH CULTIVATED SOIL.

considerable number of samples of rain- and snow-water from Paris and the country. After each distillation the apparatus has been carefully cleansed by exposing it for some time to currents of vapor, and the analysis has been tested by repeating it in blank. More than eighty essays have given identical results. The quantity of alcohol contained in rain-, snow-, and sea-water may be estimated at from one to several millionths of the whole. Cold water and snow-water seem to contain a little larger proportion of it than warm water. Appreciable quantities of it are found in the water of the Seine; and the proportion is very sensibly increased in sewer-water. Vegetable mold appears to be rich in it; and it is probable that the natural alcohol originates in the soil from the fermentation of the organic matters contained in it, and is thence diffused as a vapor in the atmo-

sphere. Meteoric waters absorb it at the moment of their condensation. These results are absolutely new, to our knowledge, and are the fruits of an entirely original labor.

THE MODERN DEVELOPMENT OF FARADAY'S CONCEPTION OF ELECTRICITY.*

By Professor H. HELMHOLTZ.

THE majority of Faraday's own researches were connected, directly or indirectly, with questions regarding the nature of electricity, and his most important and most renowned discoveries lay in this field. The facts which he has found are universally known. Nevertheless, the fundamental conceptions by which Faraday has been led to these much-admired discoveries have not been received with much consideration. His principal aim was to express, in his new conceptions, only facts, with the least possible use of hypothetical substances and forces. This was really a progress in general scientific method, destined to purify science from the last remnants of metaphysics. Now that the mathematical interpretation of Faraday's conceptions regarding the nature of electric and magnetic force has been given by Clerk Maxwell, we see how great a degree of exactness and precision was really hidden behind his words, which to his contemporaries appeared so vague or obscure; and it is astonishing in the highest degree to see what a large number of general theories, the methodical deduction of which requires the highest powers of mathematical analysis, he has found, by a kind of intuition, with the security of instinct, without the help of a single mathematical formula.

The electrical researches of Faraday, although embracing a great number of apparently minute and disconnected questions, all of which he has treated with the same careful attention and conscientiousness, are really always aiming at two fundamental problems of natural philosophy: the one more regarding the nature of physical forces, or of forces working at a distance; the other, in the same way, regarding chemical forces, or those which act from molecule to molecule, and the relation between these and the first.

The great fundamental problem which Faraday called up anew for discussion was the existence of forces working directly at a distance without any intervening medium. During the last and the beginning of the present century the model after the likeness of which nearly all physical theories had been formed was the force of gravitation acting

* The Faraday Lecture, delivered before the Fellows of the Chemical Society in the Theatre of the Royal Institution, London, on Tuesday, April 5, 1881, by Professor Helmholtz. Abstract revised by the author.

between the sun, the planets, and their satellites. It is known how, with much caution and even reluctance, Sir Isaac Newton himself proposed his grand hypothesis, which was destined to become the first great and imposing example, illustrating the power of true scientific method.

But then came Oerstedt's discovery of the motions of magnets under the influence of electric currents. The force acting in these phenomena had a new and very singular character. It seemed as if it would drive a single isolated pole of a magnet in a circle around the wire conducting the current, on and on without end, never coming to rest. Faraday saw that a motion of this kind could not be produced by any force of attraction or repulsion, working from point to point. If the current is able to increase the velocity of the magnet, the magnet must react on the current. So he made the experiment, and discovered induced currents; he traced them out through all the various conditions under which they ought to appear. He concluded that somewhere in a part of the space traversed by magnetic force there exists a peculiar state of tension, and that every change of this tension produces electro-motive force. This unknown hypothetical state he called provisionally the electrotonic state, and he was occupied for years and years in finding out what was this electrotonic state. He discovered at first, in 1838, the dielectric polarization of electric insulators, subject to electric forces. Such bodies show, under the influence of electric forces, phenomena perfectly analogous to those exhibited by soft iron under the influence of the magnetic force. Eleven years later, in 1849, he was able to demonstrate that all ponderable matter is magnetized under the influence of sufficiently intense magnetic force, and at the same time he discovered the phenomena of diamagnetism, which indicated that even space, devoid of all ponderable matter, is magnetizable; and now, with quite a wonderful sagacity and intellectual precision, Faraday performed in his brain the work of a great mathematician without using a single mathematical formula. He saw with his mind's eye that, by these systems of tensions and pressures produced by the dielectric and magnetic polarization of space which surrounds electrified bodies, magnets or wires conducting electric currents, all the phenomena of electro-static, magnetic, electro-magnetic attraction, repulsion, and induction could be explained, without recurring at all to forces acting directly at a distance. This was the part of his path where so few could follow him; perhaps a Clerk Maxwell, a second man of the same power and independence of intellect, was necessary to reconstruct in the normal methods of science the great building, the plan of which Faraday had conceived in his mind and attempted to make visible to his contemporaries.

Nevertheless, the adherents of direct action at a distance have not yet ceased to search for solutions of the electro-magnetic problem. The present development of science, however, shows, as I think, a

state of things very favorable to the hope that Faraday's fundamental conceptions may in the immediate future receive general assent. His theory, indeed, is the only existing one which is at the same time in perfect harmony with the facts observed, and which at least does not lead into any contradiction against the general axioms of dynamics.

It is not at all necessary to accept any definite opinion about the ultimate nature of the agent which we call electricity.

Faraday himself avoided as much as he could giving any affirmative assertion regarding this problem, although he did not conceal his disinclination to believe in the existence of two opposite electric fluids.

For our own discussion of the electro-chemical phenomena, to which we shall turn now, I beg permission to use the language of the old dualistic theory, because we shall have to speak principally on relations of quantity.

I now turn to the second fundamental problem aimed at by Faraday, the connection between electric and chemical force. Already, before Faraday went to work, an elaborate electro-chemical theory had been established by the renowned Swedish chemist, Berzelius, which formed the connecting link of the great work of his life, the systematization of the chemical knowledge of his time. His starting-point was the series into which Volta had arranged the metals according to the electric tension which they exhibit after contact with each other. A fundamental point which Faraday's experiment contradicted was the supposition that the quantity of electricity collected in each atom was dependent on their mutual electro-chemical differences, which he considered as the cause of their apparently greater chemical affinity. But, although the fundamental conceptions of Berzelius's theory have been forsaken, chemists have not ceased to speak of positive and negative constituents of a compound body. Nobody can overlook that such a contrast of qualities, as was expressed in Berzelius's theory, really exists, well developed at the extremities, less evident in the middle terms of the series, playing an important part in all chemical actions, although often subordinated to other influences.

When Faraday began to study the phenomena of decomposition by the galvanic current, which of course were considered by Berzelius as one of the firmest supports of his theory, he put a very simple question; the first question, indeed, which every chemist speculating about electrolysis ought to have answered. He asked, What is the quantity of electrolytic decomposition if the same quantity of electricity is sent through several electrolytic cells? By this investigation he discovered that most important law, generally known under his name, but called by him the law of definite electrolytic action.

Faraday concluded from his experiments that a definite quantity of electricity can not pass a voltametric cell containing acidulated water between electrodes of platinum without setting free at the negative electrode a corresponding definite amount of hydrogen, and at the

positive electrode the equivalent quantity of oxygen, one atom of oxygen for every pair of atoms of hydrogen. If, instead of hydrogen, any other element capable of substituting hydrogen is separated from the electrolyte, this is done also in a quantity exactly equivalent to the quantity of hydrogen which would have been evolved by the same electric current.

Since that time our experimental methods and our knowledge of the laws of electrical phenomena have made enormous progress, and a great many obstacles have now been removed which entangled every one of Faraday's steps, and obliged him to fight with the confused ideas and ill-applied theoretical conceptions of some of his contemporaries. We need not hesitate to say that, the more experimental methods were refined, the more the exactness and generality of Faraday's law was confirmed.

In the beginning, Berzelius and the adherents of Volta's original theory of galvanism, based on the effects of metallic contact, raised many objections against Faraday's law. By the combination of Nobili's astatic pairs of magnetic needles with Schweigger's multiplicator, a coil of copper wire with numerous circumvolutions, galvanometers became so delicate that the electro-chemical equivalent of the smaller currents they indicated was imperceptible for all chemical methods. With the newest galvanometers you can very well observe currents which would want to last a century before decomposing one milligramme of water, the smallest quantity which is usually weighed on chemical balances. You see that, if such a current lasts only some seconds or some minutes, there is not the slightest hope to discover its products of decomposition by chemical analysis. And, even if it should last a long time, the feeble quantities of hydrogen collected at the negative electrode can vanish, because they combine with the traces of atmospheric oxygen absorbed by the liquid. Under such conditions a feeble current may continue as long as you like without producing any visible trace of electrolysis, even not of galvanic polarization, the appearance of which can be used as an indication of previous electrolysis. Galvanic polarization, as you know, is an altered state of the metallic plates which have been used as electrodes during the decomposition of an electrolyte. Polarized electrodes, when connected by a galvanometer, give a current which they did not give before being polarized. By this current the plates are discharged again and returned to their original state of equality.

This depolarizing current is indeed a most delicate means of discovering previous decomposition. I have really ascertained that under favorable conditions one can observe the polarization produced during some seconds by a current which decomposes one milligramme of water in a century.

Products of decomposition can not appear at the electrodes without motions of the constituent molecules of the electrolyte throughout the

whole length of the liquid. This subject has been studied very carefully, and for a great number of liquids, by Professor Hittorff, of Münster, and Professor G. Wiedemann, of Leipsic.

Professor F. Kohlrausch, of Würzburg, has brought to light the very important fact that, in diluted solutions of salts, including hydrates of acids and hydrates of caustic alkalies, every atom under the influence of currents of the same density moves on with its own peculiar velocity, independently of other atoms moving at the same time in the same or in opposite directions. The total amount of chemical motion in every section of the fluid is represented by the sum of the equivalents of the cation gone forward and of the anion gone backward, in the same way as in the dualistic theory of electricity, and the total amount of electricity flowing through a section of the conductor corresponds to the sum of positive electricity going forward and negative electricity going backward.

This established, Faraday's law tells us that, through each section of an electrolytic conductor, we have always equivalent electrical and chemical motion. The same definite quantity of either positive or negative electricity moves always with each univalent ion, or with every unit of affinity of a multivalent ion, and accompanies it during all its motions through the interior of the electrolytic fluid. This we may call the electric charge of the atom.

Now, the most startling result, perhaps, of Faraday's law is this: If we accept the hypothesis that the elementary substances are composed of atoms, we can not avoid concluding that electricity also, positive as well as negative, is divided into definite elementary portions, which behave like atoms of electricity. As long as it moves about on the electrolytic liquid, each atom remains united with its electric equivalent or equivalents. At the surface of the electrodes decomposition can take place if there is sufficient electro-motive power, and then the atoms give off their electric charges and become electrically neutral.

Now arises the question, Are all these relations between electricity and chemical combination limited to that class of bodies which we know as electrolytes? In order to produce a current of sufficient strength to collect enough of the products of decomposition without producing too much heat in the electrolyte, the substance which we try to decompose ought not to have too much resistance against the current. But this resistance may be very great, and the motion of the ions may be very slow—so slow indeed that we should need to allow it to go on for hundreds of years before we should be able to collect even traces of the products of decomposition; nevertheless, all the essential attributes of the process of electrolysis could subsist. If you connect an electrified conductor with one of the electrodes of a cell filled with oil of turpentine, the other with the earth, you will find that the electricity of the conductor is discharged unmistakably more

rapidly through the oil of turpentine than if you take it away and fill the cell only with air.

Also in this case we may observe polarization of the electrodes as a symptom of previous electrolysis. Another sign of electrolytic conduction is, that liquids brought between two different metals produce an electro-motive force. This is never done by metals of equal temperature, or other conductors which, like metals, let electricity pass without being decomposed.

The same effect is also observed even with a great many rigid bodies, although we have very few solid bodies which allow us to observe this electrolytic conduction with the galvanometer, and even these only at temperatures near to their melting-point. It is nearly impossible to shelter the quadrants of a delicate electrometer against being charged by the insulating bodies by which they are supported.

In all the cases which I have quoted one might suspect that traces of humidity absorbed by the substances or adhering to their surface were the electrolytes. I show you, therefore, this little Daniell's cell, in which the porous septum has been substituted by a thin stratum of glass. Externally, all is symmetrical at both poles; there is nothing in contact with the air but a closed surface of glass, through which two wires of platinum penetrate. The whole charges the electrometer exactly like a Daniell's cell of very great resistance, and this it would not do if the septum of glass did not behave like an electrolyte. All these facts show that electrolytic conduction is not at all limited to solutions of acids or salts.

Hitherto we have studied the motions of ponderable matter, as well as of electricity, going on in an electrolyte. Let us study now the forces which are able to produce these motions. It has always appeared somewhat startling to everybody who knows the mighty power of chemical forces, the enormous quantity of heat and of mechanical work which they are able to produce, and who compares with it the exceedingly small electric attraction which the poles of a battery of two Daniell's cells show. Nevertheless, this little apparatus is able to decompose water.

The quantity of electricity which can be conveyed by a very small quantity of hydrogen, when measured by its electrostatic forces, is exceedingly great. Faraday saw this, and has endeavored in various ways to give at least an approximate determination. The most powerful batteries of Leyden-jars, discharged through a voltameter, give scarcely any visible traces of gases. At present we can give definite numbers. The result is, that the electricity of one milligramme of water, separated and communicated to two balls one kilometre distant, would produce an attraction between them equal to the weight of twenty-five thousand kilos.

The total force exerted by the attraction of an electrified body upon another charged with opposite electricity is always proportional

to the quantity of electricity contained in the attracting as on the attracted body, and therefore even the feeble electric tension of two Daniell's elements, acting through an electrolytic cell upon the enormous quantities of electricity with which the constituent ions of water are charged, is mighty enough to separate these elements and to keep them separated.

We now turn to investigate what motions of the ponderable molecules require the action of these forces. Let us begin with the case where the conducting liquid is surrounded everywhere by insulating bodies. Then no electricity can enter, none can go out through its surface, but positive electricity can be driven to one side, negative to the other, by the attracting and repelling forces of external electrified bodies. This process, going on as well in every metallic conductor, is called "electrostatic induction." Liquid conductors behave quite like metals under these conditions. Professor Wüllner has proved that even our best insulators, exposed to electric forces for a long time, are charged at last quite in the same way as metals would be charged in an instant. There can be no doubt that even electro-motive forces going down to less than $\frac{1}{100}$ Daniell produce perfect electrical equilibrium in the interior of an electrolytic liquid.

Another somewhat modified instance of the same effects is afforded by a voltametric cell containing two electrodes of platinum, which are connected with a Daniell's cell, the electro-motive force of which is insufficient to decompose the electrolyte. Under this condition the ions carried to the electrodes can not give off their electric charges. The whole apparatus behaves, as was first accentuated by Sir W. Thomson, like a condenser of enormous capacity.

Observing the polarizing and depolarizing currents in a cell containing two electrodes of platinum, hermetically sealed and freed of all air, we can observe these phenomena with the most feeble electro-motive forces of $\frac{1}{1000}$ Daniell, and I found that down to this limit the capacity of the platinum surfaces proved to be constant. By taking greater surfaces of platinum I suppose it will be possible to reach a limit much lower than that. If any chemical force existed besides that of the electrical charges, which could bind all the pairs of opposite ions together, and require any amount of work to be vanquished, an inferior limit to the electro-motive forces ought to exist, which forces are able to attract the atoms to the electrodes and to charge these as condensers. No phenomenon indicating such a limit has as yet been discovered, and we must conclude, therefore, that no other force resists the motions of the ions through the interior of the liquid than the mutual attractions of their electric charges.

On the contrary, as soon as an ion is to be separated from its electrical charge we find that the electrical forces of the battery meet with a powerful resistance, the overpowering of which requires a good deal of work to be done. Usually the ions, losing their electric charges,

are separated at the same time from the liquid; some of them are evolved as gases, others are deposited as rigid strata on the surface of the electrodes, like galvanoplastic copper. But the union of two constituents having powerful affinity to form a chemical compound, as you know very well, produces always a great amount of heat, and heat is equivalent to work. On the contrary, decomposition of the compound substances requires work, because it restores the energy of the chemical forces which has been spent by the act of combination.

Metals uniting with oxygen or halogens produce heat in the same way, some of them, like potassium, sodium, zinc, even more heat than an equivalent quantity of hydrogen; less oxidizable metals, like copper, silver, platinum, less. We find, therefore, that heat is generated when zinc drives copper out of its combination with the compound halogen of sulphuric acid, as is the case in a Daniell's cell.

If a galvanic current passes through any conductor, a metallic wire, or an electrolytic fluid, it evolves heat. Mr. Prescott Joule was the first who proved experimentally that, if no other work is done by the current, the total amount of heat evolved in a galvanic circuit during a certain time is exactly equal to that which ought to have been generated by the chemical actions which have been performed during that time. But this heat is not evolved at the surface of the electrodes, where these chemical actions take place, but is evolved in all the parts of the circuit, proportionally to the galvanic resistance of every part. From this it is evident that the heat evolved is an immediate effect, not of the chemical action, but of the galvanic current, and that the chemical work of the battery has been spent in producing only the electric action.

If we apply Faraday's law, a definite amount of electricity passing through the circuit corresponds to a definite amount of chemical decomposition going on in every electrolytic cell of the same circuit. According to the theory of electricity, the work done by such a definite quantity of electricity which passes, producing a current, is proportionate to the electro-motive force acting between both ends of the conductor. You see, therefore, that the electro-motive force of a galvanic circuit must be, and is, indeed, proportionate to the heat generated by the sum of all the chemical actions going on in all the electrolytic cells during the passage of the same quantity of electricity. In cells of the galvanic battery chemical forces are brought into action able to produce work; in cells in which decomposition is occurring work must be done against opposing chemical forces; the rest of the work done appears as heat evolved by the current, as far as it is not used up to produce motions of magnets or other equivalents of work.

Hitherto we have supposed that the ion with its electric charge is separated from the fluid. But the ponderable atoms can give off their electricity to the electrode and remain in the liquid, being now elec-

trically neutral. This makes almost no difference in the value of the electro-motive force. For instance, if chlorine is separated at the anode it will remain at first absorbed by the liquid; if the solution becomes saturated, or if we make a vacuum over the liquid, the gas will rise in bubbles. The electro-motive force remains unaltered. The same may be observed with all the other gases. You see in this case that the change of electrically negative chlorine into neutral chlorine is the process which requires so great an amount of work, even if the ponderable matter of the atoms remains where it was.

The more the surface of the positive electrode is covered with negative atoms of the anion and the negative with the positive ones of the cation, the more the attracting force of the electrodes exerted upon the ions of the liquid is diminished by this second stratum of opposite electricity covering them. On the contrary, the force with which the positive electricity of an atom of hydrogen is attracted toward the negatively charged metal increases in proportion as more negative electricity collects before it on the metal and the more negative electricity collects behind it in the fluid.

Such is the mechanism by which electric force is concentrated and increased in its intensity to such a degree that it becomes able to overpower the mightiest chemical affinities we know of. If this can be done by a polarized surface, acting like a condenser, charged by a very moderate electro-motive force, can the attractions between the enormous electric charges of anions and cations play an unimportant and indifferent part in chemical affinity?

You see, therefore, if we use the language of the dualistic theory and treat positive and negative electricities as two substances, the phenomena are the same as if equivalents of positive and negative electricity were attracted by different atoms, and perhaps also by the different values of affinity belonging to the same atom, with different force. Potassium, sodium, zinc, must have strong attraction to a positive charge; oxygen, chlorine, bromine, to a negative charge.

Faraday very often recurs to this to express his conviction that the forces termed chemical affinity and electricity are one and the same. I have endeavored to give you a survey of the facts in their mutual connection, avoiding, as far as possible, introducing other hypotheses, except the atomic theory of modern chemistry. I think the facts leave no doubt that the very mightiest among the chemical forces are of electric origin. The atoms cling to their electric charges and the opposite electric charges cling to the atoms. But I don't suppose that other molecular forces are excluded, working directly from atom to atom. Several of our leading chemists have begun lately to distinguish two classes of compounds, molecular aggregates and typical compounds. The latter are united by atomic affinities, the former not. Electrolytes belong to the latter class.

If we conclude from the facts that every unit of affinity of every

atom is charged always with one equivalent, either of positive or of negative electricity, they can form compounds, being electrically neutral, only if every unit charged positively unites under the influence of a mighty electric attraction with another unit charged negatively. You see that this ought to produce compounds in which every unit of affinity of every atom is connected with one and only with one other unit of another atom. This is, as you will see immediately, indeed, the modern chemical theory of quantivalence, comprising all the saturated compounds. The fact that even elementary substances, with few exceptions, have molecules composed of two atoms, makes it probable that even in these cases electric neutralization is produced by the combination of two atoms, each charged with its electric equivalent, not by neutralization of every single unit of affinity.

But I abstain from entering into mere specialties, as, for instance, the question of unsaturated compounds ; perhaps I have gone already too far. I would not have dared to do it if I did not feel myself sheltered by the authority of that great man who was guided by a never-erring instinct of truth. I thought that the best I could do for his memory was to recall to the minds of the men, by the energy and intelligence of whom chemistry has undergone its modern astonishing development, what important treasures of knowledge lie still hidden in the works of that wonderful genius. I am not sufficiently acquainted with chemistry to be confident that I have given the right interpretation—that interpretation which Faraday himself would have given, perhaps, if he had known the law of chemical quantivalence, if he had had the experimental means of ascertaining how large the extent, how unexceptional the accuracy of his law really is ; and if he had known the precise formulation of the law of energy applied to chemical work, and of the laws which determine the distribution of electric forces in space as well as in ponderable bodies, transmitting electric current or forming condensers. I shall consider my work of to-day well rewarded if I have succeeded in kindling anew the interest of chemists for the electro-chemical part of their science.

GLUCOSE AND GRAPE-SUGAR.

By Professor HARVEY W. WILEY.

THE manufacture of sirup and sugar from corn-starch is an industry which, in this country, is scarcely a dozen years old, and yet it is one of no inconsiderable magnitude. On August 1, 1880, ten glucose-factories were in operation in the United States, consuming daily about twenty thousand bushels of corn. These, with their several capacities, are as follows :

Firmenich's, Buffalo	4,000 bushels.
Buffalo, Buffalo	5,000 "
American, Buffalo	3,000 "
Higher, St. Louis	1,000 "
Peoria Refinery, Peoria	2,500 "
Peoria Grape-sugar, Peoria	850 "
Davenport, Davenport, Iowa	1,500 "
Freeport, Freeport, Illinois	1,500 "
Duryea, Brooklyn	1,500 "
Sagetown, Sagetown, Illinois	250 "

At that time, also, there were in process of construction nine factories, with a total capacity of twenty-two thousand bushels daily.

At the same time additional machinery was in process of erection in the two Peoria factories, which increased their capacity two thousand and twenty-five hundred bushels, respectively.

The new factories were building in—

Detroit	capacity,	3,000 bushels.
Chicago	"	10,000 "
Geneva, Illinois	"	1,000 "
Iowa City	"	1,500 "
Danville, Illinois	"	1,500 "
Tippecanoe, Ohio	"	500 "
Rockford, Illinois	"	1,000 "
Pekin, Illinois	"	500 "
Marshalltown, Iowa	"	3,000 "

We may safely assume that at the present time one half of these new factories are in running order. The total daily consumption of corn, therefore, for sugar- and sirup-making, is not far from thirty-five thousand bushels.

Eleven million bushels of corn during the present year will be used for this purpose, and every indication leads us to believe that the amount will be doubled in 1882.

The capital invested in this sugar industry is likewise no inconsiderable one. Taking the large and small establishments together, each thousand bushels of daily capacity represents sixty thousand dollars of capital. Over two million dollars are therefore actively employed in the glucose-works. The number of men employed amounts to about sixty for each thousand bushels capacity, making a total of twenty-one hundred. On account of the nature of the process of manufacture, the mills are run night and day, and work is not entirely suspended on Sunday.

To avoid confusion of ideas, the following statements seem necessary: The word *glucose*, in this country, is employed among dealers to designate exclusively the thick sirup which is made from corn-starch. On the other hand, *grape-sugar* is applied to the solid product obtained from the same source. The *glucose* and *grape-sugar* of the

trade have optical and chemical properties quite different from many other substances bearing the same name. I shall use the words in the signification explained above.

Properties of Glucose.—Glucose is a thick, tenacious sirup, almost colorless, or of a yellowish tint. It has an average specific gravity, at 20° C., of 1·412. That which is made for summer consumption is a little denser than that manufactured for winter use. This sirup is so thick that, in the winter, it is quite difficult to pour it from one vessel to another.

The sweetness of glucose—i. e., the intensity of the impression it makes on the nerves of taste—varies greatly with different specimens. Some kinds approach in intensity the sweetness of cane-sugar, while others seem to act slowly and feebly. It has been shown that the degree of sweetness depends on the extent of the chemical changes which go on in the conversion of starch into sugar. When the process of conversion is stopped as soon as the starch has disappeared, the resulting glucose has a maximum sweetness.* The color of glucose depends on the thorough washing of the substance, during the process of manufacture, through animal charcoal, and lowness of temperature at which it is evaporated, and rapidity of evaporation. The methods of securing these conditions will be described further on.

There is one variety of glucose which is made for confectioners' use, which is much thicker and denser than that just described. Its specific gravity may reach 1·440, but it has no tendency to become hard and solid, like the so-called grape-sugar.

The grape-sugar made from corn-starch, when well made, is pure white in color when first made, but has a tendency to assume a yellowish tint when old. It is hard and brittle, does not usually take on a visible crystalline structure, and is less soluble in water than cane-sugar. Perhaps it would be more accurate to say that it dissolves more slowly, since both cane- and grape-sugar dissolve in all proportions in hot water. I have found its specific gravity to be as high as 1·6. It is much less sweet to the taste than glucose, and a faint bitter after-taste is to be perceived.

Uses of Glucose and Grape-Sugar.—Glucose is used chiefly for the manufacture of table-sirups, candies, as food for bees, for brewing, and for artificial honey.

It is impossible at present to get any reliable statistics concerning the amount of glucose used in beer-making. The brewers themselves try to keep its use a secret, since it is quite common to proclaim that beer is made from barley and hops alone, although this is rarely the case. Dealers and manufacturers are likewise reticent when approached on this subject, since it is but natural for them to wish to protect the interests of their patrons. We shall not go far wrong, however, when

* See paper read by the author at the Boston meeting of the American Association for the Advancement of Science.

we say that the amount of glucose used by brewers is by no means small, and that the quantity is constantly increasing. I do not know any reason why its moderate use should injure the quality of the beer.

Bees eat glucose with the greatest avidity, or, rather, they act as funnels by which the glucose is poured into the comb. For it is quite true that honey made by bees which have free access to glucose differs scarcely at all from the glucose itself. But the quantity of honey which a bee will store away when fed on glucose is truly wonderful. This gluttony, however, rapidly undermines the apiarian constitution, and the bee rarely lives to enjoy the fruits of its apparent good fortune. In commercial honey, which is entirely free from bee mediation, the comb is made of paraffine, and filled with pure glucose by appropriate machinery. This honey, for whiteness and beauty, rivals the celebrated real white-clover honey of Vermont, but can be sold at an immense profit at one half the price.

All soft candies, waxes, and taffies, and a large proportion of stick-candies and caramels, are made of glucose. Very often a little cane-sugar is mixed with the glucose, in order to give a sweeter taste to the candies, but the amount of this is made as small as possible. As has been stated above, the glucose which is used in confections is evaporated nearer to dryness than that which is used for sirups. In such glucoses I have found the percentage of water to be as low as 6·37. Such a product is almost thick enough for "taffy" without any further concentration.

A very large percentage of all the glucose made is used for the manufacture of table-sirups. The process of manufacture is a very simple one :

The glucose is mixed with some kind of cane-sugar sirup until the tint reaches a certain standard. The amount of cane-sugar sirup required varies from three to ten per cent., according to circumstances. These sirups are graded A, B, C, etc., the tint growing deeper with each succeeding letter.

When these sirups are sent into the shops, they are sold to consumers under such altisonant names as "Maple Drip," "Bon Ton," "Upper Ten," "Magnolia," "Extra Choice," "Golden Drip," "White-Loaf Drip," etc. Dealers tell me that these sirups, by their cheapness and excellence, have driven all the others out of the market. So much is this the case that it is no longer proper to call glucose the "coming sirup." It is the sirup which has already come.

In addition to the uses above mentioned, small quantities of glucose are used by vinegar-makers, tobacconists, wine-makers, distillers, mucilage-makers, and perhaps for some other purposes.

Grape-sugar is also used for many of the purposes enumerated above, but chiefly for the adulteration of other sugars. When it is reduced to fine powder, it can be mixed with cane-sugar in any proportions, without altering its appearance. Since the grape-sugar costs less than

half the price of cane-sugar, this adulteration proves immensely profitable. The presence of grape-sugar in table-sugars can be approximately determined by several simple tests. When placed on the tongue, the bitter after-taste, already spoken of, may be detected. If spread in a thin layer on a piece of glass, and treated with a little water, the cane-sugar granules dissolve first, and the grape-sugar is left as a flocculent mass. With the microscope, its particles can be detected by the absence of all crystalline structure. Its exact quantity can only be determined by the polariscope. This is hardly a proper place to describe how this is done.

From the best information I can obtain, it appears that the cost of manufacture of glucose and grape-sugar is about one cent a pound. From twenty-six to thirty-two pounds are made from a bushel of corn. It is sold by the manufactories at three to four cents per pound. In the West the price of corn during the last year has averaged a little over thirty cents per bushel. It thus appears that the manufacture of glucose is a profitable industry.

I shall attempt here no detailed statement of the method of manufacture, but give only such an outline as may interest those who like to know how the things on their tables are prepared. The corn is first soaked for two or three days in warm water, and is then ground on specially prepared stones with a stream of water. The meal is next passed into a trough, the bottom of which is made of fine bolting-cloth. Here the starch is washed through, and led to large tanks, where it is allowed to settle. It is next beaten up with caustic soda to separate the gluten, and the starch is again allowed to settle in long, shallow troughs. The starch, washed from all adhering alkali, is next beaten up with water into a cream, and conducted into the converting-tubs. These tubs are supplied with coils of copper steam-piping and are made of wood. Here the starch-cream is treated with dilute sulphuric acid, and steam is allowed to bubble up through the mixture from small holes in the copper pipes. This process of conversion, which is called "open conversion," is completed in about two hours.

Another method is called "close conversion." The substances are inclosed in stout copper cylinders, and subjected to the action of superheated steam. This process occupies about fifteen minutes.

The conversion is also accomplished sometimes by fermentation. This requires a much longer time. The greater part of it, however, is carried on by the method first named.

After conversion the acid is neutralized by marble-dust and animal charcoal. Since the sulphate of calcium, which is formed in this operation, is slightly soluble in water, carbonate of barium has been used instead of marble-dust. Its use, however, has not become general.

After neutralization the liquid is filtered through cloth and animal charcoal, and is then conveyed to the vacuum-pan. Here it is evapo-

rated, at as low a temperature as possible, to the required concentration. If grape-sugar is to be made, the process of conversion is not stopped as soon as the starch has disappeared, but is carried on still further to a point which can only be determined by trial. After concentration it is conveyed into tanks, where the process of solidification begins and continues for several days.

Glucose, on the other hand, will not harden, whatever the degree of concentration may be, or, at least, if it do so, only partially and after many months.

The habit of bleaching both glucose and grape-sugar by means of sulphurous acid is sometimes practiced, but is reprehensible. By the oxidation of the sulphurous acid, free sulphuric acid is likely to occur in the finished product.

Glucose and grape-sugar are mixtures of several chemical substances. Starch, which is composed of six atoms of carbon, ten of hydrogen, and five of oxygen, when subjected to the action of dilute sulphuric acid, appears to undergo a molecular condensation and hydration. Among the substances formed may be reckoned dextrine, glucose, and a substance isomeric with cane-sugar. This latter substance appears to be one of the early products of conversion, and this is the reason that the poorly converted glucoses are sweeter than the well converted. It is only after prolonged boiling with dilute acid that the product becomes chemically homogeneous, with a constitution which is probably represented by the symbol $C_6H_{12}O_6H_2O$.

Glucose presents several anomalies when examined with polarized light. Its highest rotatory power is found when it is made with the least possible amount of conversion—i. e., when the process of conversion is stopped as soon as the starch has disappeared. Continued boiling with dilute acid causes a gradual decrease of rotatory power. It is only after six to eight hours' heating to a temperature of 104° C. that a constant rotatory power is reached. This power is only about half that exhibited by the glucose as a maximum. This minimum rotatory power, however, is greater than that possessed by cane-sugar.

Glucose, like many other bodies, has the property of reducing a hot alkaline copper solution and separating the metal as a red sub-oxide. This power in glucose is always inversely as the rotating power. I have shown this fully and conclusively in the paper already referred to. The relation between reducing power and rotating power is a constant one, and hence the percentage of reducing power can be calculated from the polarimetric observations. This, however, is of more interest to the practical chemist than to the general reader, and I therefore pass it by.

The question of most practical importance is, "Is glucose a wholesome article of food?" I do not hesitate to answer this question in the affirmative. I mean by this, however, a glucose which is properly made. Such a glucose contains only a very little sulphuric

acid and lime, not much more than good spring-water, and perhaps an almost infinitesimal trace of copper, so slight as only to be detected in a large quantity of the substance. I do not doubt but that glucoses have been sold which contain large quantities of free sulphuric acid and likewise other injurious ingredients. But these are due to carelessness in manufacture, and are not constituents of the genuine article. I have never found a glucose of this kind. Many of the impurities which have been imputed to glucose, really belong to the cane-sirups with which they have been mixed. These largely adulterated glucoses should always be looked upon with suspicion. The cane-sirups, which are used for this purpose, yield from three to five per cent. of ash, while the ash from a genuine glucose is so little as to be almost unweighable.

There is no reason to believe that a glucose or grape-sugar properly manufactured is any less wholesome than cane- or maple-sugar. Corn, the new American king, now supplies us with bread, meat, and sugar, which we need, as well as with the whisky which we could do without.

THE MENTAL EFFECT OF EARTHQUAKES.

THE outbreak of new earthquakes, first at Agram, then in Ischia, and now in Chios, the last the most destructive of all, and costing thousands of lives, within a few weeks of each other, seems to show that a period of earthquake-shock may have begun which may affect, to an extent by no means inconsiderable, the history and life of our century. No one can doubt that the earthquakes and volcanic eruptions which visited the same general region, but more especially Asia Minor and Italy, during the first and second centuries of our era, produced great effects, not only on the minds and characters of that generation, but even on the distribution of population; nor that the earthquake at Lisbon, in the last century, produced almost as great a shock on the thoughts of men as it produced physically on the immense region over which its effects were felt—a region which included almost all Europe, part of Africa, and part of the American Continent. A spell of earthquake of any violence or duration, which should extend over such a field as that, would, in a time like our own, when every influence is intensified by the simultaneous transmission of the impressions it produces to all parts of the globe, produce the most powerful effects, not simply on the countries which might suffer from it, but on all the world. No physical phenomena, however dreadful, seem to produce the same sense of paralysis as earthquakes. A correspondent of Captain Basil Hall, who was in the earthquake of Copiapo,

in 1822, describes the effect on the mind as something which begins before any other sign of the earthquake has manifested itself at all—an anticipatory horror, which is even more marked in the case of the lower animals. "Before we hear the sound, or at least are fully conscious of hearing it, we are made sensible, I do not know how, that something uncommon is going to happen; everything seems to change color; our thoughts are chained immovably down; the whole world appears to be in disorder: all nature looks different to what it is wont to do; and we feel quite subdued and overwhelmed by some invisible power, beyond human control or apprehension." In the Neapolitan earthquake of 1805, these anticipatory signs were most remarkable in relation to the life of the animal world. An Italian writer, quoted in Mr. Wittich's "Curiosities of Physical Geography," says: "I must not omit in this place to mention those prognostics which were derived from animals. They were observed in every place where the shocks were such as to be generally perceptible. Some minutes before they were felt, the oxen and cows began to bellow, the sheep and goats bleated, and, rushing in confusion one on the other, tried to break the wicker-work of the folds; the dogs howled terribly, the geese and fowls were alarmed and made much noise; the horses which were fastened in their stalls were greatly agitated, leaped up, and tried to break the halters with which they were attached to the mangers; those which were proceeding on the roads suddenly stopped, and snorted in a very strange way. The cats were frightened, and tried to conceal themselves, or their hair bristled up wildly. Rabbits and moles were seen to leave their holes; birds rose, as if scared, from the places on which they had alighted; and fish left the bottom of the sea and approached the shores, where at some places great numbers of them were taken. Even ants and reptiles abandoned, in clear daylight, their subterranean holes in great disorder, many hours before the shocks were felt. Large flights of locusts were seen creeping through the streets of Naples toward the sea the night before the earthquake. Winged ants took refuge during the darkness in the rooms of the houses. Some dogs, a few minutes before the first shock took place, awoke their sleeping masters, by barking and pulling them, as if they wished to warn them of the impending danger, and several persons were thus enabled to save themselves." What it is, before the sound or shock of earthquake is felt, which warns both animals and human beings of the approach of some dreadful catastrophe threatening the very basis of their existence, no one, of course, can say, since the impression made upon the nervous system is, at least as regards our own species, evidently one of general disturbance, and not one to which experience attaches any explicit significance. It may be, of course, that some very great change in the magnetic conditions of a spot threatened with earthquake leads to that extreme excitement of mind exhibited by all living creatures previous to the onset of the

earthquake. That, however, is pure conjecture. What is interesting is, that a certain blank consternation seems always to be the characteristic herald of an earthquake, as well as the characteristic result. That it should be the characteristic result is, of course, no wonder. The very condition of human life is the solidity of the not very thick earth-crust on which we live, and when that solidity is exchanged for positive fluidity, as it is in the worst earthquakes, it is natural enough that stupefaction should be the result. In one of the Calabrian earthquakes, it was discovered that large pieces of ground had so changed places that a plantation of mulberry-trees had been carried into the middle of a corn-field and there left, and a field sown with lupines had been carried out into the middle of a vineyard. The Italian lawsuits which resulted from this liquefaction of "real" property may be easily imagined. Still stranger, in the earthquake in Riobamba in 1797, Alexander von Humboldt found that the whole furniture of one house had been buried beneath the ruins of the next house. "The upper layer of the soil, formed of matter not possessing a great degree of coherency, had moved like water in running streams, and we are compelled to suppose that those streams flowed first downward, and at last rose upward. The motion in the shocks which were experienced in Jamaica (July 7, 1692) must have been not less complicated. According to the account of an eye-witness, the whole surface of the ground had assumed the appearance of running water. The sea and land appeared to rush on one another, and to mingle in the wildest confusion. Some persons who, at the beginning of the calamity, had escaped into the streets and to the squares of the town, to avoid the danger of being crushed under the ruins of the falling houses, were so violently tossed from one side to the other that many of them received severe contusions, and some were maimed. Others were lifted up, hurled through the air, and thrown down at a distance from the place where they were standing. A few who were in town were carried away to the seashore, which was rather distant, and then thrown into the sea, by which accident, however, their lives were saved." Such a liquefaction of all that is most solid in our world seems a grim enough realization of the prayer of the prophet: "O that thou wouldst rend the heavens, that thou wouldst come down, that the mountains might flow down at thy presence," for the mountains do really flow down in earthquakes, but the effect of that flowing is a consternation such as no other phenomenon of physical life, not even the worst darkness of volcanic eruptions, ever produces. The loss of everything stable at the basis of human life is the collapse of the ordinary foundations even of the spiritual life itself, though, if that life has got its roots firmly into the heart, the original foundations may fall away without impairing the vitality of that which at first had propped itself upon them. But, where this is not the case, nothing tends more to that truest Nihilism—which, so far from thinking it

worth while to destroy anything, finds both destruction and construction alike childish under the tottering of the very pillars of life—than the phenomena of an earthquake. Amid the moral shocks which the collapse of the very earth itself produces, only a faith which has profoundly convinced itself that the physical frame of things is a mere scaffolding, by the lines of which the spiritual dwelling of man has been fashioned, remains at all. Positivism itself, with its hierarchy of the sciences, all of them resting on the material life as the substratum of everything, would obviously disappear in a moment along with the menace to that physical foundation on which it bases its whole system.

It is curious to think what such races as the Teutonic would become under the influence of frequent earthquakes. Their "solidity" of character, as it is called, largely consists in the confidence they feel in the sameness of all Nature's ways ; and whether it would survive that confidence, and outlive the constancy on which it was nourished, is very doubtful. An English squire, for instance, whose timber and crops had changed places with the timber and estates of his next neighbor, would certainly not be recognizably an English squire much longer. An English merchant, whose stock of satins or teas had vanished under the establishment of his rival, would find the world so very much out of joint that he himself would probably become an unmeaning phenomenon. It is, indeed, clear that even rare periodical attacks of earthquake would render the existence of a great capital impossible, and the character of an agricultural population quite different, and probably much more capricious than before. And not unreasonably so. Spiritual faith, even if it remain, can not well rule the actions of physical beings in a physical world which has lost all aspects of constancy. Indeed, repeated shocks to the physical basis of things, though they may well test the strength of faith, can not of course be often repeated on this earth of ours without transferring all the characteristic operativeness of faith to a world of another kind. Faith is faith in divine constancy ; and the constancy which has ceased to govern our bodies must be discoverable in some other region, not that of our bodies, if faith is to be of use. Morally, then, the only use of earthquakes must be to *test* the growth of a spiritual faith in a world and life beyond the reach of earthquakes. Clearly it can not strengthen or educate such a faith. It can only sift the false faith from the true, and accord to the true its triumph.—*Spectator.*

SKETCH OF JULIUS ADOLPH STÖCKHARDT.

By Professor W. O. ATWATER.

A FEW miles from Dresden, in one of the many picturesque regions of Saxony, cozily stowed away at the confluence of three lovely valleys, lies the little village of Tharandt, known to a few pleasure-seekers as a charming summer resort, and to the world at large as the seat of a famous school of forestry and agriculture. On an eminence overlooking the village, and itself overlooked by the picturesque ruin of what was once a hunting-castle of the princes of Saxony, is the house; in the village below are the school, the laboratory, and the experiment station; and hard by are the experimental garden and fields where the subject of our sketch, Julius Adolph Stöckhardt, lives and labors. For nearly forty years he has been engaged, by researches, by lectures, by writing, and by the publishing of journals, in promoting and popularizing the science of chemistry, especially in its applications to the culture of the soil. In carrying science to the people, and in presenting it in such ways that the most learned can not criticise nor the most ignorant fail to understand, that every one who reads or listens shall wish to read or listen more, and that the facts when comprehended may be successfully and profitably applied to practice, few living men are his peers. And, as an author as well as interpreter of researches, Stöckhardt ranks among the ablest of the early leaders in this, the golden age of agricultural chemistry.

He was born at Röhrsdorf, near Meissen, in Saxony, January 4, 1809. After receiving a classical education, he studied pharmacy and the natural sciences for several years, and was graduated in 1833 as an apothecary of the first class. In 1834 he traveled in Belgium, England, and France, then devoted himself to pharmaceutical study and research, and in 1838 received the degree of Ph. D. from the University of Leipsic. He then entered upon the teaching of natural science in Dresden, and afterward in the technological school at Chemnitz, and was also appointed inspector of apothecaries. His rare talent for presenting scientific knowledge of matters usually obscure was soon recognized by both students and citizens, and the remarkable power of critical observation displayed in his writings ("Untersuchung der Zwickauer Steinkohle," 1840; "Ueber Erkennung und Anwendung der Giftfarbe," 1844, etc.) was the occasion of almost innumerable applications for the investigation of commercial problems, and demands for his opinion upon scientific and legal questions. In 1843 he traveled in Belgium and France to perfect himself in technological science. In 1846 he published his "Schule der Chemie," which in

1861 had reached its twelfth edition; had been translated into eight different languages, and was used by scores of thousands of students the world over. The current American translation of this work, "Stöckhardt's Principles of Chemistry," is very widely and pleasantly known among teachers and students in this country.

In 1844 Stöckhardt began a course of popular agricultural lectures before the Chemnitz Agricultural Society. To these lectures may be traced the beginning of the movement which, eight years later, resulted in the establishment at Möckern, Saxony, of the first of the agricultural experiment stations, of which there are now over one hundred in Europe and several in the United States, and from whose work, it may be said without exaggeration, has emanated a great part—perhaps the greater part—of our accurate knowledge of the principles of chemistry and physiology that underlie the right practice of agriculture. On the occasion of the celebration, in 1877, of the twenty-fifth anniversary of the founding of the Möckern Station, three albums, with photographs of the directors of the experiments at that time established, were provided: one for the parent station at Möckern, one for Professor von Wolff, its first director; and one for Professor Stöckhardt in consideration of his services in founding and promoting that and other stations.

From 1846 to 1849 Stöckhardt was editor of the "Polytechnisches Centralblatt," and from 1850 to 1855 of the "Zeitschrift für deutsche Landwirthe." In 1848 he was appointed Professor of Agricultural Chemistry in the Royal Academy at Tharandt, where a new chair had been founded purposely for him, and where he has since remained. Since then, extending his idea of popular agricultural instruction, he has given plain conversational lectures to farmers' clubs and societies in Saxony and other parts of Germany, explaining the improvement in agriculture which chemical science has shown to be desirable, and illustrating them with experiments where practicable. The more important of these lectures have been published with the title "Chemische Feldpredigten" ("Chemical Field-Sermons"), and have been translated into several languages. In 1855 he established at Leipsic "Der chemische Ackersmann," a journal which was continued until 1876, when increase of years and cares, and the doing away of its necessity by the establishment, with his aid, of another journal, "Die Landwirthschaftlichen Versuchs-Stationen," occasioned its discontinuance.

But this brief outline of his career gives very little idea of Stöckhardt as a man, an investigator, a teacher, and an expounder of the occult facts of science. To know him in these relations one must see him at his home, among his friends, in his study, his laboratory, his lecture-room, with students and farmers, and must read him in his books.

In appearance and demeanor he is plain and quiet. In social inter-

course he is approachable, kind, ready for a pleasantry, a laugh, or to impart from the great store of his learning whatever the earnest inquirer may need. In the lecture-room his talk is so simple and familiar that the most abstruse principles seem like every-day facts; and his illustrations, drawn from the ordinary and homely experiences of common life, are so clear, pat, and to the point, that one can neither fail to feel their force nor forget their application. With farmers, be they great landholders or humble peasants, his information and explanations are always plain, attractive, practical, and suited to the occasion and the men. And everywhere he is the earnest, laborious, learned, and reverent student, the kindly, faithful instructor, and the worthy man.

Among the especial services Stöckhardt has rendered as teacher and promoter of science is one which, perhaps, is best illustrated in his text-book of chemistry ("Schule der Chemie"), the setting forth of the idea that the right way to teach science is by bringing the student into direct contact with nature, by making him an observer, an investigator, and thus his own best teacher. In the preface to the twelfth edition of this book, he says:

> Experiments must be the foundation of theory. With them the beginner should learn to observe, reflect, and judge; from them he should himself unfold the general chemical relations and truths; he should himself discover, and in this way by his own efforts, along with manual dexterity, acquire an intellectual possession also. Every experiment and every fact observed therein will thus be to him a conquest, and will incite to new exertion.

Accordingly the book abounds with simple experiments to be made with apparatus which any student may get and handle, and is yet sufficient to illustrate, enforce, and impress the truths that are taught, and, what is better, to enable the learner to find the highest inspiration in working out the truths himself. How useful this system of instruction, as thus set forth by Stöckhardt, has proved, may be inferred from the wide circulation of the book as mentioned above, and the facts that sets of apparatus put up to go with it were sent to all parts of Germany, to England, and to Russia, and that a depot for their sale was established in New York.

Of Stöckhardt's greatest work, the promotion of agricultural science, perhaps the best idea may be got from his "Chemical Field-Sermons," which show his methods of popularizing science, and especially from his journal, "Der chemische Ackersmann," in which both his popular treatises and his scientific investigations have been published.

As a discoverer, Stöckhardt, though well known, is outranked by other agricultural chemists of his time. Liebig, the father of agricultural chemistry, Wolff, Henneberg, Knop, Nobbe, Stohmann, Kühn, and others in Germany, Boussingault in France, and Lawes and Gil-

bert in England, have each, perhaps, given the world more of new truth than he. Stöckhardt's chief labor has been to teach, to popularize, to encourage, and thus to promote science, and, withal, to help in its application to practical life. In this great work of mediating between science and the people for whose benefit science is, among those who have done most for agriculture, no man, except, perhaps, Justus Liebig, excels Julius Stöckhardt.

An inkling of the spirit in which Stöckhardt's labors for agriculture has been performed he has himself given us, perhaps unwittingly, in the illustration on the cover of his journal, "Der chemische Ackersmann" ("The Chemical Husbandman"). In the center is a rural scene. In the foreground, cattle and sheep are feeding in the comfort of a peaceful autumn day. Farther away, a reaper is laying down his sickle by the waving grain to follow the heavy load that is trundling homeward from the field. In another field a plowman has left his plow in the furrow, while he and his tired horses are enjoying a brief period of rest. Close by him are the bags of guano and bone-dust to replace the precious ingredients of plant-food that have been carried away with the harvest. Beyond is the little village, with its steep-roofed cottages, and the village church surrounded by shade-trees and surmounted by the tower whose bell calls the inhabitants to morning work, to vesper rest, and to Sabbath worship. Directly in front the ground has been cut away, and reveals, in the deep recesses toward which the roots of trees and herbs are seen to penetrate, a strange laboratory where imps and kobolds are busy with furnace and crucible, retort and mortar, test-tube and balance, as it were, working over the materials and concocting the compounds that are to be gathered up by the plants, and make the fruit to reward the tiller of the soil. Between this occult laboratory and the farm-work that is going on above are the words "*Praxis mit Wissenschaft*" ("Practice with science"). But this scene and motto are not all of the picture, nor do they typify the whole of the spirit of Stöckhardt's life and work. Above are clouds with sunbeams streaming brightly through them upon the earth below, and on them is written, "*An Gottes Segen ist Alles gelegen*" ("On God's blessing all depends").

EDITOR'S TABLE.

THE BUFFALO FIELD CLUB.

THERE is urgent need for more general and efficient association for popular scientific improvement. In politics, in religion, in philanthropy, in reform, and in the original extension of science, the key of influence and the secret of success are coöperation; and this is the agency to which we must look for the popular cultivation of science. The best form of associative action for the promotion of self-education in science is, undoubtedly, the field club, and we are gratified to observe that these excellent organizations are multiplying and doing admirable work. We called attention some months since to the proceedings of the Ottawa Club, and are glad now to be able to report the successful organization of a similar club in Buffalo. It is an outgrowth of the botany and geology classes in the Central High School of that city. These classes have for several years made excursions into the country surrounding Buffalo, under the direction of their able instructor, Professor Charles Linden. The working Field Club was organized in the spring of 1880, with over forty members, and proved successful from the beginning. Professor Linden, the director, is an ardent student and a skillful instructor, and seems to have imbued the members with much of his own enthusiasm for science. The field meetings have been attended on all occasions by a majority of the members. In order to systematize their work, the club is organized into sections in botany, geology, and entomology, and they are now busy in providing cases to arrange and preserve whatever has been collected in the field. Several members have nearly complete collections of the local flora and of geological specimens representing the formations of the vicinity; the entomological branch, which begins work this spring under the direction of Professor Kellicott, of the State Normal School, will no doubt make rapid progress during the coming season and contribute to the increasing success of the club.

Experience has shown that these organizations are only too often ephemeral, and are generally weakened by the prolonged interruption of winter when the excitement passes off, and they need to be freshly stimulated every spring. But there is interesting winter work as well as summer work in science. The Buffalo club has therefore held its meetings all along during the winter in the spacious library of the Society of Natural Sciences. At these semi-monthly meetings papers have been read before the club, followed by their discussion, and an exhibition of specimens necessary to illustrate all the main points upon which beginners are in relative ignorance. When needed, the calcium light and screen have been used to enhance the interest of illustration. The meetings have been well attended by the members, their friends, and local scientists; they have been profitable for instruction, and have kept up an unbroken solicitude for the success of the association.

The twelve papers read at the semi-monthly meetings in the past season were published in the Buffalo "Daily Courier," and were well worthy of being laid before the public. We have been favored with the reports, and have read them all with interest. They are, of course, not of equal merit, nor equally relevant to the strict objects of the club; but, as a whole and as a first

trial, they are admirable. Perhaps the best of the essays are those on "The Gorge of the Niagara," "Alaska," "The Catskill Mountains," "Coal," and "The Tulip-Tree." As the club grows older, the thought of its members will no doubt be more concentrated upon objects within their immediate field of observation, and these will become the subjects of exposition at the winter meetings. It would be well, indeed, if members would take up lines of observation to be pursued during the summer, with special reference to their discussion at the winter gatherings of the club. By taking notes and reading up on the subject chosen, and doing the literary part at convenient intervals, the work would be deliberately and carefully done, and, while the student carried on his own self-instruction, the club would be a gainer by improving the standard of its winter performances.

AGNOSTICISM AT HARVARD.

THE students of Harvard University have been canvassed to ascertain their religious opinions. It has been suspected that this institution, so long the headquarters of Unitarian liberalism, has become pervaded by atheism and agnosticism. But it is now found that the believers in these doctrines are virtually nowhere in this great establishment, and that in fact it is drifting away from rationalistic Unitarianism in the direction of pronounced orthodoxy.

There is a great propensity in this country to count up and see who is ahead. Next to the prime national question, "How many dollars?" the American soul yearns to know "How many votes?" Wherever two or three are gathered together, just before election, they are sure to count noses on the nominations. That there should also be a curiosity to know who is losing, who is gaining, and who leads, in the sphere of religious rivalry, is not surprising, for with our people, next after money-getting and politics, sectarian concernments have the most urgent claims. So the Harvard students were questioned as to their spiritual preferences, with the following results: "College and Law School, 972 men; agnostics, 26; atheists, 7; Baptists, 42; Chinese, 1; Christians, 2; Dutch Reformers, 2; Episcopalians, 275; Hebrews, 10; Lutheran, 1; Methodists, 16; nonsectarian, 97; orthodox Congregational, 173; Presbyterians, 27; Quakers, 2; Roman Catholics, 33; Swedenborgians, 20; Unitarians, 214; Universalists, 18; not seen, 6." There has been a great deal of comment and no little congratulation on these unexpected results, but there is one aspect of the matter that we have not seen noticed.

From the point of view of agnosticism there are but two parties in the college, the 26 adherents to that view, and the 940 who do not accept it. The agnostic ground is that religion, in so far as it is supernatural, transcends human intelligence, so that man can really *know* nothing beyond the phenomenal and the finite. He may imagine much, and believe much, and fancy that he knows, but strictly tested it turns out that his conjectures are not knowledge in the true and proper sense. The position of the agnostic, in short, in regard to other worlds or spheres of existence beyond time, space, and the course of nature, is briefly this: "I know nothing and you know nothing, we neither of us can know anything, and we had better modestly confine our thoughts to the universe which we can know."

Now, as there are only 26 that take this ground, it is only fair to suppose that the other 940 take other and opposite ground; that is, they claim to *know* in regard to the religious matters of which they profess belief—claim, indeed, that their religious knowledge is the most clear and certain of all their knowledge.

The Harvard agnostic replies: "The condition and course of things in our

university do not look like it. Let us test your claim by reference to that religious doctrine which is here regarded as of leading importance. The lowest and most rudimentary form of intelligence undoubtedly relates to numbers. No human beings have ever been found so incapable that they could not count a little, if no more than three or four fingers. At the very dawn of intelligence there must arise a perception of the difference between one object and two or three objects. Knowledge may be said to begin here, and, as it agrees with all experience, it is beyond all other knowledge exact, fundamental, and sure. Now, when you undertake to rise above nature and experience, and pass into the realm beyond, what success have you in the application of your primary numerical ideas? Is the infinite object of worship one, two, three, or twenty? Our students are divided over the question; and the fluctuations that are observed in regard to it do not favor the notion that it rests on real knowledge. The mass of our students are not agnostics. They say they know. But, while 214 of them declare that the Divine Being is a unit, 589 of the rest deny this simple proposition, and say that the Divine Being is three or something like it. Since the third century the Church has been quarreling over the application of the most elementary arithmetic to the object of divine worship, and the swaying of opinion now indicated in Harvard University shows that the question is just as unsettled as ever. But if men can not agree in applying the very first and simplest steps of numeration in the transcendental sphere, can they be said to have any real 'knowledge' of it, and how can they succeed better in the application of higher ideas?"

But our Harvard agnostic pushes the case still further. He can say: "We have among us 275 Episcopalians, who, with the other orthodox students, make up 589 professed Trinitarians. They are not agnostics, because they 'know' about this matter; and they are not Unitarians, because they are certain that hypothesis implies a false application of primary arithmetic in the premises. They reject the idea of unity applied to the Deity as false, and condemn it as wicked, and maintain that the true hypothesis is that of tri-personality, or of three Divine persons in the Godhead. But when any one of the '589' is pushed a little to explain himself, and make his alleged 'knowledge' clear, he says, 'Forbear! it is a great mystery, above poor human reason,' and that we are not required to understand it. But that is rank agnosticism! A mystery is simply that which can not be known. So our Trinitarians, who begin by declaring their 'knowledge' of the Divine nature, when cross-questioned, take a ready refuge in the unknowable."

ANOTHER STEP IN EDUCATIONAL PROGRESS.

The great movement of the century to modernize education, and make it conform to the progress of knowledge, is most conspicuously illustrated in England. An old, vigorous, advancing nation, leading in the multifarious work of civilization, and at the same time dominated by conservative habits, and maintaining two ancient, rich, and powerful universities, rooted in the most venerable traditions, England has been well situated for the display of those important changes in which educational progress consists. The tendency of the old universities was to check the growth of thought by a slavish devotion to the learning of antiquity. The spirit of the modern study of nature penetrated them but slowly. Bacon protested against scholastic verbalism, and called men back from the study of words to the study of things. The progress was outside of England's great seats of learning; and, when it had become palpable that they were behind the age and

would not do the work demanded, other universities had to be established more in harmony with the state of knowledge. Various institutions were organized, notably the University of London, which accepted more modern standards of scholarship, and gradually recognized the claims of science as a means of education and a basis of university honors. The conflict between ancient and modern studies has continued and is still rife, but there is no doubt as to how the battle is going. We gave an account not long ago of the newly-organized Mason College, in which the comprehensive educational scheme is based upon science, and the old learning is passed by. We observe that another important step is taken in the same direction by the reorganization of Owens College, which is now known as Victoria University. The students of this college have hitherto mostly taken their degrees at the London University. But the right to confer degrees is now granted to the new university, and in drawing up their plans of study the governing body have been guided by the most liberal and enlightened views of education. They have openly repudiated the old superstition that all minds are alike and ought to pursue the same studies, and they proceed, in the language of the Vice-Chancellor, Dr. Greenwood, "upon the fundamental notion that a man of capacity ought to be encouraged to devote himself with a certain amount of concentration to some particular or definite branch of arts or science study." Of course, students can come to Victoria University and take its best degrees without knowing Latin and Greek. There are various courses, and the standard of attainment is to be high and thorough, but Latin and Greek are no longer indispensable to the acquisition of university honors. We have been a long time arriving at the very common-sense view expressed by Mr. Jacob Bright in a discussion on the policy of the university in respect to classics, that "it seemed to him extraordinary if the whole field of science and learning of various kinds apart from Latin and Greek were not enough to form the basis of a sound education."

HELMHOLTZ'S FARADAY LECTURE.

On Tuesday evening, April 5th, Professor Helmholtz, of the University of Berlin, gave the Faraday Lecture before the Chemical Society at the Royal Institution. As might have been expected, he was greeted by a distinguished audience. Professor Roscoe presided, and, before introducing the eminent German physicist, presented him with the Faraday Medal. The address, notes of which were furnished by Professor Helmholtz to the London press, is reproduced in our pages, and will be carefully read by all interested in chemical physics. It is, perhaps, the most weighty and significant tribute to the genius of Faraday that has yet been made; and at the same time it is itself no slight contribution to physico-chemical theory. It was stated that Faraday, although not a mathematician, had anticipated with great sagacity the results of electro-chemical research by the trained mathematicians of the present generation. Professor Helmholtz's original speculations were thus referred to by Dr. Roscoe: "Upon Faraday's well-known law of electrolysis he has founded a new electro-chemical theory which reveals to us chemists conclusions of the utmost importance. He tells us, as the result of the application of the modern theory of electricity to Faraday's great experimental law, that the atom of every chemical element is always united with a definite, unvarying quantity of electricity. Moreover—and this is most important—that this definite amount of electricity attached to each atom stands in close connection with the combining power of the atom which modern chemistry terms quantivalence. For, if the

amount of electricity belonging to the monad atom be taken as a unit, then that of the dyad atom is two, of the triad atom, three, and so on. Hence, then, thanks first to Faraday and now to Helmholtz, chemists have now a new and unlooked-for confirmation of one of their most important doctrines from the science of electricity."

LITERARY NOTICES.

POPULAR LECTURES ON SCIENTIFIC SUBJECTS. By H. HELMHOLTZ. Translated by E. ATKINSON, Ph. D. Second Series. New York: D. Appleton & Co. Pp. 265. Price, $1.50.

THE first series of Helmholtz's lectures met with the success which has induced Professor Atkinson to translate an additional volume of them. It is gratifying to know that the translator feels himself justified in this, as it shows a growing popular appreciation of solid intellectual work in science. The contents of this volume are considerably varied, and represent the action of Helmholtz's mind upon widely different subjects. The first paper is an *in memoriam* address on Professor Gustave Magnus, who died in 1869. The essay is not a mere biographical notice or an ordinary eulogy, but is rather an analysis of the character and the scientific labors of Magnus in connection with the state of knowledge and circumstances of his time, so that the paper becomes in some respects an interesting portion of scientific history.

The second paper is "On the Origin and Significance of Geometrical Axioms," and it was a lecture delivered in Heidelberg in 1870. This discussion is not child's play, but many will be attracted to master it because it breaks into the field of speculation with regard to the different dimensions of space.

Artists will be interested in the abstracts of five lectures "On the Relation of Optics to Painting," which were delivered in Cologne, Berlin, and Bonn. After the introductory he takes up successively the subjects, form, shade, color, and harmony of color. His point of view is neither that of the practical artist nor of the student of pictures and schools of painting, but it is that of the physiological optician who is master of a subject. He shows in various ways how a knowledge of the mode of perception of the organ of vision may be of importance to the artist.

Perhaps the most striking of all the papers is the lecture "On the Origin of the Planetary System." So much is said about the nebular hypothesis of Kant and Laplace in these evolutionary times, that many will be glad to see the subject summed up within a moderate compass, and by an authoritative hand. No man is better prepared by his broad scientific erudition and his thorough mastery of mathematical and experimental physics than Professor Helmholtz to report on the present state of knowledge regarding the origin of the planetary system. But it was very far from the author's intention to make a mere popular statement of what former inquirers have arrived at. As one of the founders of the doctrine of the conservation of forces, he may be said to have been an original contributor to the nebular theory; and he is very pointed in his remarks on the grave scientific significance of the inquiry. He says, "Science is not only entitled, but is indeed beholden, to make such an investigation. For her it is a definite and important question—the question, namely, as to the existence of limits to the validity of the laws of nature, which rule all that now surrounds us; the question whether they have always held in the past, and whether they will always hold in the future; or whether, on the supposition of an everlasting uniformity of natural laws, our conclusions from present circumstances as to the past, and as to the future, imperatively lead to an impossible state of things; that is, to the necessity of an infraction of natural laws, of a beginning which could not have been due to processes known to us. Hence, to begin such an investigation as to the possible or probable primeval history of our present world, is considered as a question of science—no idle speculation, but a question as to the limits of its methods, and as to the extent to which existing laws are valid."

Professor Helmholtz is of opinion that our planetary system must sooner or later

come to an end by the exhaustion of its forces. The sun must ultimately "run down" like a clock. He thinks that the existing stock of power available for the maintenance of life may last some seventeen million years, but that it must at length be spent. He thus philosophizes, in conclusion, over the phenomena of the final extinction of life:

However this may be, that which most arouses our moral feelings at the thought of a future (though possibly very remote) cessation of all living creation on the earth is, more particularly, the question whether all this life is not an aimless sport, which will ultimately fall a prey to destruction by brute force? Under the light of Darwin's great thought we begin to see that not only pleasure and joy, but also pain, struggle, and death, are the powerful means by which Nature has built up her finer and more perfect forms of life. And we men know more particularly that in our intelligence, our civic order, and our morality, we are living on the inheritance which our forefathers have gained for us, and that which we acquire in the same way will in like manner ennoble the life of our posterity. Thus the individual, who works for the ideal objects of humanity, even if in a modest position and in a limited sphere of activity, may bear without fear the thought that the thread of his own consciousness will one day break. But even men of such free and large order of minds as Lessing and David Strauss could not reconcile themselves to the thought of a final destruction of the living race, and with it of all the fruits of all past generations.

As yet we know of no fact, which can be established by scientific observation, which would show that the finer and complex forms of vital motion could exist otherwise than in the dense material of organic life; that it can propagate itself as the sound movement of a string can leave its originally narrow and fixed home, and diffuse itself in the air, keeping all the time its pitch, and the most delicate shade of its color-tint; and that, when it meets another string attuned to it, starts this again or excites a flame ready to sing to the same tone. The flame even, which, of all processes in animate nature, is the closest type of life, may become extinct, but the heat which it produces continues to exist, indestructible, imperishable, as an invisible motion, now agitating the molecules of ponderable matter, and then radiating into boundless space as the vibration of an ether. Even there it retains the characteristic peculiarities of its origin, and it reveals its history to the inquirer who questions it by the spectroscope. United afresh, these rays may ignite a new flame, and thus, as it were, acquire a new bodily existence.

Just as the flame remains the same in appearance and continues to exist with the same form and structure, although it draws every minute fresh combustible vapor and fresh oxygen from the air, into the vortex of its ascending current; and just as the wave goes on in unaltered form, and is yet being reconstructed every moment from fresh particles of water, so also in the living being, it is not the definite mass of substance, which now constitutes the body, to which the continuance of the individual is attached. For the material of the body, like that of the flame, is subject to continuous and comparatively rapid change—a change the more rapid, the livelier the activity of the organs in question. Some constituents are renewed from day to day, some from month to month, and others only after years. That which continues to exist as a particular individual is like the flame and the wave—only the form of motion which continually attracts fresh matter into its vortex and expels the old. The observer with a deaf ear only recognizes the vibration of sound as long as it is visible and can be felt, bound up with heavy matter. Are our senses, in reference to life, like the deaf ear in this respect?

THE HUMAN BODY: An Account of its Structure and Activities, and the Conditions of its Healthy Working. By H. NEWELL MARTIN, D. S. C., M. A., M. B., Professor of Biology in the Johns Hopkins University. New York: Henry Holt & Co. 1881. Pp. 655. Price, $2.75.

THIS work is a contribution to the American "Science Series" of college text-books, and is one of the best of those excellent publications that has yet appeared. Dr. Martin's task in its preparation has not been a light one; for, although he has had the most interesting of all subjects to deal with, and is herein specially fortunate, yet, on the other hand, he has had to compete in the most thoroughly cultivated field of our whole scientific literature. There are many physiological text-books of all grades, and among them are some of the best scientific manuals to be anywhere found. A new work must therefore be of exceptional excellence if it aspires to become a standard on this subject in the higher education.

We have looked over "The Human Body" carefully, and have been interested throughout. The descriptive and explanatory part is remarkably clear, and the accompanying illustrations are abundant and of a superior quality. The book has, moreover, something of a freshness and originality which seemed to be due to the breadth of Dr. Martin's preparation as a biologist. One of the difficulties, indeed, with our physiological text-books is, that they have been too generally the work of physiologi-

cal specialists and exclusive students of the human body. Human physiology of some sort is as old as the practice of medicine, but it became a new science under the influence of modern biology. The human body is only to be understood in connection with the general system of life in nature, and, as this subject has recently been greatly developed, its results should contribute much interesting interpretation to human physiology. Dr. Martin, we think, has written his work from this point of view, and that it may be taken as embodying all the latest assured advances of science in their bearing upon his subject. But, as there is no sharp boundary where accredited science stops, the author, in posting up his work, necessarily encountered the perplexity of dealing with facts and principles not yet settled, for physiology is still an actively progressive science. Dr. Martin does not avoid "disputed matters," but simply aims to do justice to the present state of his subject. He says in his preface: "This was deliberately done, as the result of an experience in teaching physiology, which now extends over more than ten years. It would have been comparatively easy to slip over things still uncertain, and subjects as yet uninvestigated, and to represent our knowledge of the workings of the animal body as neatly rounded off at all its contours, and complete in all its details—*totus, teres, et rotundis*. But, by so doing, no adequate idea of the present state of physiological science would have been conveyed; in many directions it is much further traveled and more completely known than in others; and, as ever, exactly the most interesting points are those which lie on the boundary between what we know and what we hope to know. In gross anatomy there are now but few points calling for a suspension of judgment; with respect to microscopic anatomy there are more; but a treatise on physiology which would pass by, unmentioned, all things not known but sought, would convey an utterly unfaithful and untrue idea. Physiology has not finished its course; it is not cut and dried, and ready to be laid aside for reference like a specimen in an herbarium, but is comparable rather to a living, growing plant, with some stout and useful branches well raised into the light, others but part-grown, and many still represented by unfolded buds."

We have no space to go into the method or classification of Dr. Martin's work, which seems to be lucid and convenient, while the share given to the leading subjects is well proportioned to their importance.

In one respect this manual is better than we expected to find it: it is more thoroughly practical than we were prepared to expect from an experimental biologist, and such a devotee of original scientific study as Dr. Martin is well known to be. We anticipated a valuable and trustworthy scientific treatise, but we are glad to see that the science is constantly and effectively applied to the hygienic art. The application of physiological principles for the preservation of health, the care of the body, and the improvement of the conditions of life, are copiously interspersed through the text, and they will have the effect both of increasing the student's interest in the study and of securing the first object of all education—the acquisition of knowledge indispensable to self-preservation.

VICTOR HUGO: HIS LIFE AND WORKS. From the French of ALFRED BARBOU. By FRANCES A. SHAW. Chicago: S. C. Griggs & Co. Pp. 207. Price, $1.

THE life of a man who has acquired such a hold upon a nation as Victor Hugo has gained upon the French people can not fail to be full of interest and instruction, and well deserves to be written. The great French poet and patriot has found a competent and appreciative biographer in M. Barbou, who seems to be one of his most enthusiastic admirers, and has associated with him intimately.

THE TELESCOPE: THE PRINCIPLES INVOLVED IN THE CONSTRUCTION OF REFRACTING AND REFLECTING TELESCOPES. By THOMAS NOLAN, B. S. Reprinted from "Van Nostrand's Magazine." New York: D. Van Nostrand. Pp. 75. Price, 50 cents.

THIS little book presents a brief exposition of the optical principles of lenses and mirrors, and their application to the construction of refracting and reflecting telescopes, illustrated by several figures and plates.

SIGHT, AN EXPOSITION OF THE PRINCIPLES OF MONOCULAR AND BINOCULAR VISION. By JOSEPH LE CONTE, LL. D. With numerous Illustrations. Pp. 275. D. Appleton & Co. International Scientific Series, No. XXII. Price, $1.50.

DR. LE CONTE has for many years made the eye a subject of special study, from the point of view assumed in this book. And this is the way this wonderful organ will in future have to be studied. Its interest as an object of investigation is inexhaustible. Its mechanism and action are roughly explained in every physiology; but, to state all that is known about it, in its several aspects in health and disease, would require whole libraries. Helmholtz has made a large and a profound book on physiological optics, devoted to an elucidation of the relations of light to the visual organism, while the psychological relations of the organ of vision have yet to be explored. The eye is, therefore, a subject so complex, obscure, and extensive, that it must in future be approached on different sides by separate investigators. In taking up the eye with a view of explaining the mechanism and process of sight as single and double, our author declares that he does not know the existence of "any work covering the same ground in the English language." He, therefore, claims that it meets a real want, and fills a real gap in scientific literature.

In regard to its form, Dr. Le Conte says: "I have tried to make a book that will be intelligible and interesting to the thoughtful general reader, and at the same time profitable to even the most advanced specialist in this department." It must be admitted that that the author has fairly attained to his ideal. His explanations are so clear, and his facts and principles so interesting, that they will be sure to engage the attention of ordinary readers, while at the same time he gradually passes to the consideration of questions and the presentation of views that will appeal to instructed critics as new contributions to the subject.

Another point in regard to this work strikes us as most important. It is largely a book of experiments; the effects discussed and illustrated with the woodcuts are such as can be tested by the reader who will take some pains to practice. This is an important means of education, by which the reader not only learns how to do things, but becomes acquainted with the subject at first hand, and knows what he knows. On this feature of his book, Dr. Le Conte remarks: "As a means of scientific culture, the study of vision seems to me exceptional. It makes use of, and thus connects together, the sciences of physics, physiology, and even psychology. It makes the cultivation of the habit of observation and experiment possible to all; for the greatest variety of experiments may be made without expensive apparatus, or, indeed, apparatus of any kind. And, above all, it compels one to analyze the complex phenomena of sense in his own person, and is thus a truly admirable preparation for the more difficult task of analysis of those still higher and more complex phenomena which are embraced in the science of psychology."

SKETCHES AND REMINISCENCES OF THE RADICAL CLUB OF CHESTNUT STREET, BOSTON. Edited by Mrs. JOHN T. SARGENT. Boston: James R. Osgood & Co. 1880. Pp. 418. Price, $2.

THE Radical Club was founded in the spring of 1867, with the purpose of bringing together occasionally a few persons who were known to be daring thinkers on subjects of high import, and of furnishing them "an opportunity for uttering their thought to an audience capable of appreciating its scope, of criticising its worth, and of developing its relations." It was composed of members of all religious denominations, and enjoyed an attendance of two hundred at the closing sessions of 1880. This volume contains about fifty of the essays which were presented at the meetings, with notices of the discussions which followed the reading. The authors, whose names are appended, are, as a rule, men and women known in literature, science, or the forum, whose words never fail to command attention. The subjects of their papers represent a wide range of thought in literature, art, theology, metaphysics, science, and sociology, and are of degrees of practicality of which "Color-blindness" may be taken to represent one extreme and "The Impossible in Mathematics" the other. The reports of the informal discussions are full of conventional life, and are hardly less interesting than the essays.

OUR NATIVE FERNS AND HOW TO STUDY THEM, WITH SYNOPTICAL DESCRIPTIONS OF THE NORTH AMERICAN SPECIES. By LUCIEN M. UNDERWOOD, Ph. D. Bloomington, Illinois. Pp. 116. Illustrated. Price, $1.

THE development of interest in the study of ferns is illustrated by the works treating of them, or embodying illustrations of them, that have been published in this country during the last four years. Still, they occupy a subordinate place in our botanical manuals, the descriptions of many species are stored away in inaccessible periodicals and rare books, and, till this work appeared, no manual available to students had been issued that classified all our native species, or outlined their morphology and mode of life. Professor Underwood has made, in the little manual before us, a most commendable attempt to fill this gap in botanical literature. The descriptions of genera and species are preceded by chapters describing in an engaging style the haunts, habits, distribution, morphology, fructification, structure, classification, and nomenclature, etc., of ferns, the germination of fern-spores, "How to study Ferns," and "A Little Fern Literature."

DRUGS THAT ENSLAVE: THE OPIUM, MORPHINE, CHLORAL, AND HASHEESH HABITS. By H. H. KANE, M. D. Philadelphia: Presley Blakiston. Pp. 224. Price, $1.50.

THIS book contains a great deal of information on the narcotic habit, its effects, dangers, and treatment, which is derived from the author's special experience as a medical practitioner, from wide acquaintance with the literature of the subject, and from extensive correspondence with medical men, systematically carried on for the elucidation of obscure or undetermined questions. Though the work aims to be a contribution to medical science, and is addressed to the profession, it yet has a general interest, from the prominence given to the growing dangers of narcotic indulgence among nearly all classes of society. Dr. Kane maintains that a great impulse has been given to the illegitimate use of opium by the introduction of the hypodermic syringe for the injection of morphine under the skin into the tissues. The practice with this instrument is but recent. It was introduced into this country from England in 1856, by Dr. Fordyce Barker, and has not only come into universal use by physicians, but it is much and increasingly employed by individuals, who continue the habit as a fascinating indulgence, which was begun by the doctor for the relief of painful disease. The book is full of examples of the distressing evils of narcotic indulgence, and abounds in warnings against its insidious approaches and deadly results.

REMINISCENCES OF DR. SPURZHEIM AND GEORGE COMBE. A Review of the Science of Phrenology from the Time of its Discovery by Dr. Gall, to the Time of the Visit of George Combe to the United States, in 1838–'40, with a new Portrait of Spurzheim. By NAHUM CAPEN, LL. D. New York: Fowler & Wells. Pp. 262. Price, $1.50.

THE author was a personal friend and confidential assistant of Spurzheim during his visit to the United States, and is thoroughly versed, as an active sympathizer, with the school of thought of which he was a conspicuous representative from the beginning. He has prepared his reminiscences in answer to what he believes to be a general demand, and has incorporated in it many interesting recollections concerning other advocates of the phrenological school, as Drs. Gall, George Combe, and Andrew Combe.

HISTORY OF THE FREE-TRADE MOVEMENT IN ENGLAND. By AUGUSTUS MONGREDIEU. New York: G. P. Putnam's Sons. Pp. 188. Price, 50 cents.

THE question naturally occurs to the observer of national progress, who is also a student of political and economical literature, why, when the majority of the scientific writers and thinkers of all nations agree in approving the principles of free trade, statesmen set them at naught, and only one state, England, has yet adopted them and put them in practice; and they may ask further, What conditions have prompted that country to take a different course from its neighbors? This little book undertakes to answer these questions. It does more. Protectionists assert that England has been declining since it adopted free trade. It answers these assertions by

setting forth "the exact truth as embodied in historical and statistical facts of undeniable authenticity."

IS CONSUMPTION CONTAGIOUS, AND CAN IT BE TRANSMITTED BY MEANS OF FOOD? By HERBERT C. CLAPP, A. M., M. D. Boston and Providence: Otis Clapp & Son. 1881. Pp. 178. Price, $1.25.

CONSIDERABLE evidence is offered in this work tending to show that, "to a certain extent, at least, and under certain conditions, consumption is contagious." This evidence is derived from incidents in the history of the disease, the statements of physicians, and special reports of twenty-five cases. The subjects of contagion in cattle, the possibility of the transmission of tuberculosis by means of food, and the inoculability of tubercle, are also considered.

THE SPIRIT OF EDUCATION. By M. L'Abbé AMABLE BÉESAU. Translated by Mrs. E. M. McCarthy. Syracuse: C. W. Bardeen. Pp. 325. Price, $1.25.

THIS little work, by a pious French ecclesiastic, is said to have been very popular in his country. Its author is a Catholic priest, and the work is written from the point of view of the system he represents. It is endorsed by high authorities of the Church as a volume to which Catholics may look with confidence. An interesting feature of the book is its numerous extracts from the writings of eminent Catholics in past times on the subject of education. As might be expected, there is very little recognition of science in the work, and no reference to the more urgent of the modern questions that are agitating the public on the subject of education. It might have been written a thousand years ago.

LECTURES ON ELECTRICITY IN ITS RELATIONS TO MEDICINE AND SURGERY. By A. D. ROCKWELL, A. M., M. D. New York: William Wood & Co. Pp. 99. Price, $1.

THESE lectures deal chiefly with the practical points of the subject, and give special consideration to the methods of general faradization and central galvanization—methods already familiar by name to the profession, but which the author thinks might be better understood and appreciated.

THE LOGIC OF CHRISTIAN EVIDENCES. By G. FREDERICK WRIGHT. Andover: Warren F. Draper. 1880. Pp. 306. Price, $1.50.

IN consequence of the constant changes in the condition of the world and the lines of thought, each generation approaches the subject of the evidences of Christianity from a slightly different point of view. Hence a re-presentation of the subject, corresponding with the new conditions, is always in place. The author regards the power of Christianity to adjust itself in form to different degrees of civilization, while its substance remains unchangeable, as in fact one of the evidences; for the power is a consequence of its spiritual nature, and of its independence of transitory phases of intellectual and social development. The aim of this treatise is to bring into view the external and the internal evidences of Christianity as they now stand, and as they appear when compared with the evidences on which the beliefs of science are based.

FIRST GERMAN BOOK, AFTER THE NATURAL OR PESTALOZZIAN METHOD, FOR SCHOOLS AND HOME INSTRUCTION. By JAMES H. WORMAN, A. M. New York and Chicago: A. S. Barnes & Co. Pp. 63. Price, 35 cents.

THIS book is intended for beginners wishing to learn the spoken language of Germany, which is taught in it by direct appeal to illustrations of the objects mentioned, and without the use of English. The author has designed in it to present in a few pages all the essentials of German grammar so as to make their mastery easy, and prepare the student, after going through it, to enter upon the study of the more recondite, complicated, and irregular principles of the language.

PUBLICATIONS RECEIVED.

Tom Paine on Trial, and the Infidels in Court. Brooklyn: D. S. Holmes. Pp. 87. Price, 25 cents.

On Statical Electro-Therapeutics, or Treatment of Disease by Franklinism. By W. J. Morton, M. D. New York. 1881. Pp. 28.

Trances and Trancoidal States in the Lower Animals. By George M. Beard, A. M., M. D. 1881. Pp. 17.

Observations on Jupiter. By L. Trouvelot. Pp. 23.

On the Geographical Distribution of the Indigenous Plants of Europe and the Northeast United States. By Joseph F. James. 1881. Pp. 18.

Abstract of Transactions of the Anthropological Society of Washington, D. C., with the Annual Address of the President, for the First Year, ending January 20, 1880, and for the Second Year, ending January 18, 1881. Prepared by J. W. Powell. Washington: National Republican Printing-House. Pp. 150.

Report of the Cruise of the United States Revenue Steamer Corwin in the Arctic Ocean. With Meteorological Abstracts. By Captain C. L. Hooper, U. S. R. M. Washington: Government Printing-Office. 1880. Pp. 74.

A Dictionary of Music and Musicians (A. D. 1450-1881). Edited by George Grove, D. C. L. Part XIII. Planche to Richter. London and New York: Macmillan & Co. Pp. 128. Price, $1.

Quarterly Report of the Chief of the Bureau of Statistics relative to the Imports, Exports, Immigration, and Navigation of the United States for the Three Months ended December 31, 1880. Pp. 130.

On the Variation of the Leaf-Scars of *Lepidodendron Aculeatum* (Sternberg). With Plates. Pp. 16. On the Variations of the Decorticated Leaf-Scars of Certain Sigillariæ. With Plates. Pp. 5. On the Identity of Certain Supposed Species of Sigillaria with Sigillaria Lepidodendrifolia (Brongniart). With Plate. Pp. 5. By Herman L. Fairchild. From the "Annals of the New York Academy of Sciences."

The Nature of Vibration in Extended Media, and the Polarization of Sound. By S. W. Robinson. Philadelphia. 1881. Pp. 12.

Thoughts on Agricultural Education. By E. Lewis Sturtevant, M. D., South Framingham, Massachusetts. 1881. Pp. 19.

The "Spoils" System and Civil-Service Reform in the Custom-House and Post-Office at New York. By Dorman B. Eaton. New York: G. P. Putnam's Sons. Pp. 123. Price, 50 cents.

A Fourth State of Matter. By Alexander E. Outerbridge, Jr. Philadelphia. 1881. Pp. 11.

Notes on North American Microgasters, with Descriptions of New Species. By C. V. Riley, M. A., Ph. D. From the "Transactions of the Academy of Sciences of St. Louis," April 6, 1881. Pp. 20.

The Infidel Pulpit. A Study of Ingersoll. By George Chainey. Boston. Pp. 8. Price, 5 cents.

The Microscope and its Relation to Medicine and Pharmacy. Edited and published by Charles H. Stowell, M. D., and Louisa Reed Stowell, M. S. An Illustrated Bi-monthly Journal. Vol. I, No. 1. Pp. 32. Price $1 a year.

Physiology in Thought, Conduct, and Belief. By Daniel Clark, M. D., Medical Superintendent Asylum for the Insane, Toronto. 1881. Pp. 15.

Rapid Breathing as a Pain-Obtunder in Minor Surgery, Obstetrics, the General Practice of Medicine, and of Dentistry. By W. G. A. Bonwill, D. D. S. Pp. 16.

On the Geology of Florida. By Eugene A. Smith. With a Plate. From the "American Journal of Science," April, 1881. Pp. 17.

The "Journal of Physiology." By Michael Foster, M. D., F. R. S. Vol. III. No. 1, August, 1880; 2, January, 1881, and Supplement. Published in America under the Auspices of the Johns Hopkins University. Pp. 92, 70, 68. Price, $5 a year.

Contributions to the Anatomy of the Milk-Weed Butterfly, *Danais Archippus* (Fabr.). By Edward Burgess, Secretary of the Boston Society of Natural History. With Plates. Boston: Published by the Society. Pp. 16.

"The Magazine of Art." London, Paris, and New York: Cassell, Petter, Galpin & Co. April, 1881. Pp. 34. Price, 35 cents.

Modern Architectural Designs and Details: for Dwellings, Stores, Offices, and Cottages. Part VI. Plates 41 to 48. New York: Bicknell & Comstock. Price, $1.

The Student's Dream. Chicago; Jansen, McClurg & Co. 1881. Pp. 97. Price, $1.

The Dirt-Cure. By T. L. Nichols, M. D. New York: M. L. Holbrook & Co. 1881. Pp. 88. Price, 50 cents.

Imaginary Quantities: Their Geometrical Interpretation. Translated from the French of M. Argand. By Professor A. S. Hardy. New York: D. Van Nostrand. 1881. Pp. 135. Price, 50 cents.

Locke's Conduct of the Understanding. Edited, with Introduction, Notes, etc., by Thomas Fowler, M. A. Oxford: Clarendon Press. 1881. Pp. 136. Price, 50 cents.

Second German Book, after the Natural or Pestalozzian Method. By James H. Worman, A. M. New York: A. S. Barnes & Co. 1881. Pp. 81. Price, 40 cents.

Working Drawings, and how to make and use them. By Lewis M. Haupt. Philadelphia: Joseph M. Stoddard & Co. 1881. Pp. 53. With Thirty Figures.

Pocket Pronunciation-Book. By E. V. De Graff, A. M. Syracuse, New York: C. W. Bardeen. 1881. Pp. 46. Price, 15 cents.

Short History of Education. Being Articles in the ninth edition of the Encyclopædia Britannica. Edited by W. H. Payne, A. M. Syracuse, New York: C. W. Bardeen. 1881. Pp. 105. Price, 50 cents.

Coöperation as a Business. By Charles Barnard. New York: G. P. Putnam's Sons. 1881. Pp. 234. Price, $1.

The School of Life. By William R. Alger. Boston: Roberts Brothers. 1881. Pp. 205. Price, $1.

How to tell the Parts of Speech. By the Rev. Edwin A. Abbott, D. D. American edition, revised and enlarged. By J. G. R. McElroy, A. M. Boston: Roberts Brothers. 1881. Pp. 143. Price, 75 cents.

Report on Foreign Life-Saving Apparatus. By Lieutenant D. A. Lyle. Washington: Government Printing-Office. 1880. Pp. 45. With Nineteen Plates.

Annual Report of the Operations of the United States Life-Saving Service for the Fiscal Year ending June 30, 1880. Washington: Government Printing-Office. 1880. Pp. 391. With Plates.

The Origin of Primitive Superstitions. By Rushton M. Dorman. Philadelphia: J. B. Lippincott & Co. 1881. Pp. 398. Price, $3. Illustrated.

Second Report of the United States Entomological Commission for the Years 1878 and 1879. Relating to the Rocky Mountain Locust and the Western Cricket. Washington: Government Printing-Office. 1880. Pp. 424. With Map and Illustrations.

POPULAR MISCELLANY.

Diseases and the Weather.—A paper read by Dr. Henry B. Baker, Secretary of the Michigan State Board of Health, before the Sanitary Convention of that State, furnishes some interesting facts concerning the relation of meteorological conditions and particular diseases. Meteorological reports are received from about thirty observers in different parts of the State, who record the

facts of the state of the weather three times a day, and reports of health are received regularly. The reports, as a whole, show how certain diseases vary with the season, and indicate that relations exist, for instance, between the great heat of summer and the amount of sickness from diarrhœa, cholera-morbus, cholera-infantum, etc., and between the cold, dry air in winter and spring and the increase of sickness from pneumonia and similar diseases, which nearly disappear during the warm months. In several years the sickness from pneumonia increased slightly in September, decreased slightly in October, about the time of the Indian summer, and then gradually rose as cold weather set in. When the facts are represented in diagrams, a correspondence appears to be shown between the changes in certain features of the weather and the progress of particular diseases. Thus, the line representing the amount of ozone at night for 1879 nearly agrees with the line representing the prevalence of pneumonia. The bronchitis line is nearly parallel with these, while the lines representing zymotic diseases run in an opposite direction. It is unsafe, however, to lay too much stress on these coincidences, for it is not probable that the amount of ozone was accurately measured. Intermittent fever was at its highest from July to September, remittent fever in August, typho-malarial fever in September, typhoid fever in November, and cerebro-spinal meningitis was irregular, prevailing most from January to March.

Skull-Worship.—"Skull-Worship in the Pacific Ocean" was the title of an address recently made by Herr J. D. C. Schmeltz before a scientific society in Hamburg. The Museum Godefroy in Hamburg has several skulls which have been adorned with stripes over the eyebrows; on some a triangle has been traced in red, from the apex of which another red stripe has been drawn down the nose, with black stripes on either side of it. In other specimens a red line has also been drawn from the apex of the triangle to the roof of the skull, ending there in a spiral on either side. It was already known that the under jaws, if not the whole skulls, of dead relatives were often peculiarly adorned and highly honored in New Guinea. Herr Schmeltz, observing similarly painted skulls in the New Britain Islands, has concluded that a like *cultus* exists there. Herr Kleinschmidt, of the Museum Godefroy, relates that at stated times a kind of priestly person, called at Pall-Pall the Duk-Duk, or religion-man, collects the skulls of the dead and commits them to the care of their relatives; and he has sent to the museum a skull from there, in which the fleshy parts are represented by plaster and the eyes by a snail-shell, and the whole is painted. On one of the New Hebrides Islands whole skeletons of deceased persons have been exhumed, endowed with a flesh prepared from vegetable matters, and installed in the temples. A traveler on the German man-of-war Ariadne sent the museum at Hamburg a skull from the Island of Isabel (Solomon Islands) which had been browned with smoke, and with it the statement that, "when prominent men, who have distinguished themselves in war or by superior power, die, they enjoy after death a particular reverence, which appears to originate in the belief that the spirit of the dead man passes over to his worshiper and makes him fit for similar deeds. After the body has remained for a half-year in the earth, the grave is opened and the skull taken out. It is then subjected to a course of various processes, especially to a protracted smoking, after which it is deposited in the temple as an object of worship."

Chesapeake Zoölogical Laboratory.—The fourth annual session of the Chesapeake Zoölogical Laboratory of Johns Hopkins University was to begin at Beaufort, North Carolina, May 2d, and will continue till the end of August. Dr. W. K. Brooks, Associate in Biology and Assistant Professor of Comparative Anatomy, has charge as director. The laboratory is designed for advanced students, and for persons who are qualified to carry on original investigations. No definite courses of instruction are given, as the persons who are received as students are presumed to have sufficient knowledge to carry on their studies without such aid. An elementary class will also be conducted in connection with the laboratory, during about six weeks of the summer, at which daily lectures will be given, and ar-

rangements made for systematic work in the laboratory, and a part of the class will be allowed to join each day in the dredging and collecting expeditions. Dr. Brooks will exercise personal supervision of the work of this class, and will give a course of lectures on general zoölogy, but the students will be under the more immediate guidance of Dr. S. F. Clarke, who will lecture daily on the structure and habits of marine animals. Beaufort, on account of its diversified fauna, and of its mild and uniform climate, is described as a desirable place for study during the hot months of summer.

Trees and Lightning.—Professor Colladon, of Geneva, published the conclusion several years ago that, when lightning strikes a tree, it is received on the ends of the branches, which, being excellent conductors, lead it, without suffering disturbance, down to the larger limbs. Thence it descends to the main limbs and the trunk, whose conducting power, intrinsically inferior to that of the smaller and younger shoots of the top, is insufficient to sustain the concentrated force of the currents which have united here from the thousand channels by which they have so far descended. Here, then, generally appear the first marks of the shock, not because the lightning has struck the tree at that place, as might be superficially supposed, but because the conducting powers of the tree begin to fail at this point. This view was satisfactorily confirmed by the effect of the lightning upon a poplar-tree, which was struck at Geneva on the 5th of May, 1880. The young, tender leaves of the main topmost branch of this tree and of the branches immediately below it were torn up into small fragments, which strewed the ground below them, as if they had undergone a violent shock of air, such as would be produced by an explosion of dynamite. Many trees may be compared, in respect to their power to conduct electricity, to structures of wood or masonry, which are well furnished with conductors on their upper part, but with which no conducting connection with the ground is given. If such a building were struck with lightning, its upper part would not be hurt, while its lower part would suffer badly. The danger of being struck by lightning, to which persons standing under a tree are exposed, is thus accounted for. The top of the tree, bristling with conducting twigs, attracts the lightning; the current, meeting with non-conducting obstacles at the trunk, jumps from it to the surrounding bodies, whether they be bushes or men and animals. Of two persons, one standing under the tree, the other sitting among the limbs at the top, the latter would be in a vastly safer position. Birds having nests in trees are rarely struck by lightning, and their nests are hardly ever damaged. Large trees growing near a house will protect it from lightning, provided there is no pond or well or stream beyond the house to attract the current across it. If the water is on the same side of the house as the tree, or the tree is between it and the house, or has a rod attached to it, the protection is almost perfect. When a vineyard is struck by lightning, the leaves over a large circuit will, a few hours or days afterward, appear discolored, showing that the electrical action has taken place in a diffused manner, and not in a concentrated attack. In such cases hundreds or even thousands of vines may be affected, showing palpably that it is the property of lightning to manifest itself upon the whole top of a tree or a plot of vegetation. In his memoir on this subject, M. Colladon mentions a single stroke of lightning which left its traces on more than two thousand things.

Progress of Cremation.—Cremation is growing in favor throughout Europe. The first furnace for the purpose was erected at Milan, in 1875; the second, built at Gotha, in 1878, has been recognized by the authorities of the city, so that there the choice between burial and cremation is free to every citizen. Several societies for the advancement of the rite have been formed, some of them even in states where no preparations have been made for performing it. The International Hygienic Congress which met at Milan in September, 1880, adopted a resolution in favor of compelling the bodies of all animals dying of contagious diseases to be incinerated, and of the provision of facilities for that purpose in every parish. It also appointed a special international

committee to draft and present to the several governments within a year a series of propositions for expediting the adoption of cremation. A third furnace for cremation has been built at Woking, England, but has not been used. The society having charge of it, although it is assured by the Government that the execution of its purposes will not be interfered with by the law, is seeking to obtain an express sanction of them from the Government, with the expectation that a measure recognizing cremations properly performed with an efficient apparatus will impose restrictions against the irregularities of indiscriminate cremations, and against the use of defective apparatus.

Glacial Action in the Yellowstone Valley.—Mr. William H. Holmes has furnished the "American Naturalist," from the unpublished report of the Government survey, an account of the glacial phenomena in the Yellowstone Park, which are manifested in a variety of forms, chiefly in erratic rocks scattered everywhere, and in the glaciation of rocks *in situ* in the narrow gorges. It is not always safe to assume that the presence of a bowlder in a particular spot indicates the former existence of a glacier there, for the rock may have been carried to a considerable distance by a force-torrent or by a gradual, creeping movement caused by the undermining of the soil underneath; nevertheless, we have every reason to believe that glaciers formerly existed in the park on a very extensive scale. Glacial moraines are curiously absent from the region; and the tens of thousands of bowlders that dot both sides of the Yellowstone Valley generally lie on the smooth surface of the flood-planes of the river, or on low ridges of alluvial drift. "The significance of this fact may be that the transporting glaciers existed in the earlier stages of the erosion of the valley, and that the morainal ridges have been destroyed by the river, as it oscillated from side to side in the succeeding stages of its descent from the plateau-level to its present bed. These great bowlders would, in such a case, be the more durable masses of the moraines stranded on the various flood-planes for want of water-power to transport them." In seeking for the source of the granite bowlders, it is observed that they occur to a great extent on the south side of the valley, and at all elevations, while the only bodies of similar rock within the valley are found either on the north side or on the bottom at no considerable elevation above the level of the river. Either, then, the bowlders must have been transported to their present positions before the valley existed, or the ice-streams must have been so deep as to fill the valley to the brim and thus carry and strand them. In the latter case, if the glacier followed the course of the valley, the bowlders must have crossed the whole width of it after the manner of a ferry. "This could really occur only in case there should be such an increase in the masses of ice descending from the highlands to the north as to completely fill the valley, sweep across its course and overspread the broad table-land to the south." This table-land, the park plateau, is wholly volcanic, extends for a hundred miles to the south, and is separated from the base of the granite highlands on the north by the valley of the Yellowstone proper and by the East Fork. A great bowlder more than two thousand cubic feet in size which was noticed near the brink of the cañon, and a mile and a half below the great falls, must have come either from the granite highland north of the valley, in which case it must have crossed the valley of the East Fork and the third cañon, and ascended the river for twenty miles, avoiding Amethyst Mountain and the Washburn range by a circuitous route, or, less probably, from the Gallatin Mountains, also twenty miles away, when it must have had to cross the valley of the Upper Gardiner River and the spurs of the Washburn Mountain. If it be admitted, as all the evidence seems to indicate, that the ice-rivers bringing down the erratic blocks of granite came from the north, "it becomes at once clear that the erosion of the grand cañon has been accomplished since the close of the glacial period, or at least that a second erosion has taken place if a cañon existed prior to the glacial epoch."

Refrigeration and Animal Heat.—Dr. Paul Delmas, of Bordeaux, has published the results of some experiments in refrigerating a healthy person by exposing him, dur-

ing from a quarter of a minute to five minutes, to a bath of water at 50°, in which he took notice of the temperature of the subject during the exposure and every five minutes in succeeding hours. During the application of the cold, while the subject showed every sign of very intense sensations, the temperature of the body hardly varied at all, or, at most, less than half a degree from that recorded in the beginning. It still varies but little after the application is over, if, having been dried and dressed, the subject remains perfectly still; but if he exert himself actively, either immediately or after a time of immobility, so as to bring on the external phenomena of cold reaction, the temperature suddenly falls. The reduction persists for several hours, and is more pronounced as the sensation of heat in the subject is stronger. On the other hand, if chill continue or reappear, the animal temperature either does not fall or begins to rise again. The pulse suddenly becomes very quick at the beginning of the cold application; its velocity diminishes after a few seconds, and by the end of the experiment returns to the original rate, or falls below it. The retardation stops or progresses slowly if the subject keeps quiet, but becomes more pronounced and persistent as he gives signs of energetic reaction and of a general sensation of heat.

The Reality of Hypnotic Phenomena.—The "Lancet" publishes an article of Dr. Charles Richet, considering the reality of the phenomena of hypnotism. It is impossible to fix upon a decisive test in this matter. We know that a fact is scientifically certain when the phenomenon, which is the evidence of it, can be reproduced at will by all persons who will use the same processes, as in the case of any chemical or physical manipulation. The phenomena of hypnotism are uncertain, intangible, and variable; different persons, even though employing identical processes, are liable to obtain very different results. The only absolute sign possible is one's own experience, and that is applicable only to himself. There are, however, certain arguments which bear upon the case with almost, if not quite, the force of a demonstration. First, it is absurd to suppose that all hypnotized persons have simulated sleep. Friends, in whom we have absolute confidence, may be among them; it is not possible to believe that they have conspired all at once to deceive us. Second, a close agreement has prevailed among certain of the phenomena of the manifestations for sixty years. "That would be a very strange simulation to be reproduced so often, in so long a time, with the same appearances—closed eyelids, fibrillar movements in the muscles of the face, hallucinations of vision and hearing, catalepsy, contracture"—and this among persons strangers to each other and who may be wholly ignorant of hypnotism. Third, many of the phenomena can not be simulated without a profound knowledge of anatomy and physiology, which hardly any hypnotics possess. When the nerves of the hypnotized person are pressed, the muscles supplied by them contract. Who among them knows what muscles should act under the influence of a particular nerve? Yet no mistake is made. "With somnambulists one can, by direct incitation, cause contraction of the muscles (rudimentary in man) moving the auricle of the ear. Now, this contraction is impossible in the individual when awake." With a certain hysteric, who came under Dr. Richet's observation, "by opening the right eye aphasia was produced; while, by opening the left eye, no such effect was obtained. Certainly, if this be simulation, one must assume that the patient knows that speech is affected by the left cerebral hemisphere, and that the retina of the right eye is in relation with this hemisphere, while the right hemisphere is useless for speech." The hysterical contractures afford equally convincing evidence. "There is no individual strong enough to preserve voluntarily the contraction of a muscle during a quarter of an hour without one perceiving in it the slightest tendency to weakness or relaxation. Now, somnambulists maintain their contractures for many hours, and on waking they have no recollection of, no fatigue from, this prolonged and improbable effort." Again, insensibility may be feigned; "but how many persons are there who would have the courage to bear, without serious reason, pricks in the face, on the nostrils, or hands; to allow their hair

to be plucked out, and the conjunctiva, the nose, and the ears to be tickled; to have pins thrust into the arms; to drink nauseous liquids; to breathe with delight ammonia or sulphurous acid?" Somnambulists oppose no resistance to tests like these. "Must we suppose that they exhibit heroism (and a very misplaced heroism) or anæsthesia?" It is objected that the phenomena of somnambulism are incompatible with the facts of science. But, if they are themselves facts, they can not be overthrown by *a priori* reasoning. Another objection has been made: that everything observed in hypnotism is inconstant, irregular, mobile, and that the phenomena vary with every observer and with each subject. The same is the case with other psychological phenomena, and the diversities may, in all cases, be perfectly explained by the prodigious complexity of the mind. "We ought to be really struck by the resemblances rather than the differences, for the latter are of small account relatively to what they might be."

Gradual Disappearance of the Larger Animals.—The species among the different classes of animals which exceed their congeners in size are now more than ever threatened with extermination. The progressive diminution in their numbers has been more rapid during the recent geological period because they have had man as their competitor; and the present age may be destined to witness their entire disappearance. In consequence of the new competition opposed by man, more formidable than any other that the large animals have had to meet, many species have already become extinct, and many of those which are still represented among living beings are daily diminishing in numbers. The animals comprising these species, being those which are hunted with profit, or those the destruction of which is important for human security, are for these reasons inevitably the most exposed to be driven from every region in which the privileged being has established his abode. In the struggle which they have to sustain against the new rivalry they labor under the two marked disadvantages, as compared with smaller animals, that they require a more abundant supply of food and that their reproduction is less frequent and more limited, so that the losses they endure are hardly repaired. The smaller species keep up their numbers, and even increase, in consequence of their extreme fertility, in spite of the most persistent efforts of man to exterminate them. The larger animals would be totally destroyed in a very short time if they had to suffer the same proportion of losses. It is hardly rash to assert that the whales, the cachalots, the *Sirenidæ*, the morses, certain species of seals and otaries, the great white bear of the Arctic coasts, and the other bears, the large carnivorous cats (lions, tigers, etc.), the gorillas, the great armadillo, the great ant-eater, the giraffes, the elan, the aurochs, the bison, the elephants, the hippopotamuses, the rhinoceroses, the great kangaroo, the elephantine turtles, the crocodiles, the birds of the ostrich group, the great penguin of the frozen sea, etc., are threatened with the fate that has within a few centuries befallen the enormous epiornis of Madagascar, the gigantic moas of New Zealand, and within less than two centuries the dodo and the giant bird of the Island of Mauritius, the two latter species representing the largest columbid and the tallest waterfowl that have ever existed. The great carnivora are already fast disappearing before the bullets of emulous lion and tiger hunters; the whales and other larger mammalia are becoming scarce. The largest of the deer, the elan, is less widely distributed than formerly; the largest of wild cattle, the aurochs, which formerly ranged over all Europe, is now found only in the forests of Lithuania and Moldavia; the bison no longer covers the prairies with boundless herds; the great armadillo is disappearing from South America, and the great kangaroo from Australia; and the numbers of the other animals we have named are gradually diminishing. It is time for science to be busy in completing the study of these animals before some of their species go to join the ranks of those which are represented only in fossils.—*La Nature.*

Mechanical Vibrations as a Remedy in Neuralgia.—M. Boudet de Paris and Dr. J. Mortimer-Granville have published observations upon the application of mechanical vi-

brations as a remedy for neuralgia. The publication of M. Boudet de Paris was earliest in time; but Dr. Mortimer-Granville has been prosecuting researches on the subject for several years, while he intended to withhold the results from the public until the efficacy of the new remedy could be fully established. The publication of M. Boudet de Paris has, however, made it necessary for him to describe his own views and experiments, so far as he has gone, though he still considers them unperfected. His attention was drawn to the subject by the success of applications of ice in alleviating neuralgic pains in labor. Having persuaded himself that if the nerve affected in such pains could be strongly impressed, so as to change its state of irritation, the pain would cease, he tried the effect of tapping over the fifth nerve in ordinary facial neuralgia. The results were "very remarkable." He then devised an instrument, a *percuteur*, which would give a known number of blows in a second. The operations of this instrument were remarkable, although they are not yet considered decisive as to its efficacy. In numerous instances, pain was arrested by its application, and did not return. When applied over a healthy nerve, which was so situated as to be thrown readily into mechanical vibration, it produced a sensation like that caused by the passage of a weak, interrupted current of electricity, changing, when the action was prolonged, into a sensation of tingling, then of numbness, and finally to some twitching of the superficial muscles. A nervous headache, or *migraine*, could be produced by an application to the frontal ridges or the margins of the orbit. In some instances, when pain existed, the sensation was aggravated by the augmented state of vibration into which the nerve was thrown through the shaking of the adjacent tissues. It is noteworthy that a comparatively high number of vibrations per second seems to relieve a dull, aching, or grinding pain, while an acutely pitched and quick pain is most frequently arrested by a slower movement of the instrument. This is in harmony with the theory that the pain is the result of abnormal nervous vibration, and that the operation of the *percuteur* is to arrest those motions by opposing counter and interfering vibrations to them. M. Boudet de Paris relates in his paper that, by the aid of a large tuning-fork and sounding-board, he caused hemianæsthesia to disappear; provoked contractions in hysterical patients at the Sâlpetrière as rapidly as with the magnet or electricity; and subdued the pains of an ataxic. With a modified apparatus he was able to produce local analgesia, often anæsthesia, in a healthy man, or a sensation of approaching vertigo, with a desire for sleep. An attack of *migraine* could be cut short by the application. Neuralgia, especially of the fifth nerve, disappeared after a few minutes' application of the instrument; but it was more difficult to get good results with the deeper-seated nerves. Both gentlemen suggest that the action of metallo-therapy, or of metallic applications, is best explained on the theory of vibrations.

Some Facts about Explosions.—Mr. Cornelius Walford has lately attempted to collate the statistics of explosions, as a help to ascertaining their causes and the means of avoiding them. A large increase in such disasters, which has been remarked in modern times, is easily accounted for when we remember that we deal with explosive materials and machinery vastly more than our ancestors did. The returns of the deaths from explosions in England and Wales, during twenty-two of the years between 1852 and 1879, give a total of 6,814, or 309 a year, of which 187 a year were ascribed to explosions of fire-damp, 37 to those of boilers, and 70 to those of chemicals, including gunpowder. Assuming, as the insurance companies do, that one hundred persons are hurt by such accidents where one is killed, a proportion which is not confirmed by the figures that follow, we have an annual average of 30,900 persons injured by explosions in England and Wales. No means exist of ascertaining the amount of property destroyed. Explosions of chemicals are increasing in frequency and variety of character as new processes are introduced in the arts. Remarkable instances of these occurred at Gateshead in 1854, when, during a fire, nitrate of soda and sulphur, neither of which would explode alone or in simple combinations, exploded terribly when water was brought to bear

upon them; in the explosion of bisulphide of carbon in a shoddy-oil factory in 1867; and in a celluloid-factory at Newark, New Jersey, in 1879. An explosion, believed to be of carbonic acid, which occurred in a French coal-mine, is supposed to have been caused by the formation, from the decomposition of pyrites, of sulphuric acid, which, finding its way to the limestone, suddenly generated large quantities of gas. M. Kuhlmann has shown that sulphuric acid mixing with ten equivalents of water may cause a very violent explosion. Of 156 colliery explosions, recorded in the United Kingdom during the present reign, the largest numbers occurred in February, March, and December, and the smallest number in May. Help in the study of disasters of this class is expected from meteorological investigations. Dust has recently been found to be a formidable explosive, and is now believed to have nearly as much to do with coal-mine accidents as fire-damp. The charred appearance of the wood-work in coal-mines after explosions is ascribed to the deposition of a crust of scorched or melted coal-dust upon it. The fine dust generated in some of the processes employed in flouring-mills has been recognized lately as a very dangerous source of explosions, and attention has been directed to the contrivance of improvements in machinery to mitigate the perils to which the workers in tens of thousands of mills are exposed from it. The dangers arising from the liability of illuminating-gas to explode are great enough, but they would be much increased if a process should be adopted for depriving the gas of its odor. The explosive properties of gunpowder and petroleum in all the ways in which they are used are familiar enough and dreaded. The frequent damage to powder-mills by lightning may be ascribed not so much to the attractive power of the substances stored in them as to their isolated situation on marsh-lands near rivers. Insurance-tables show that 1,536 explosions of steam-boilers have taken place in the United Kingdom during the present century, killing 2,293 persons and injuring 3,259. In the United States, 1,299 explosions, killing 2,506 persons and injuring 2,612, are recorded as having taken place between October 1, 1867, and January 1, 1880. The largest number of these were in saw, planing, and wood-working mills, the next largest in steam-vessels, and the next largest of railroad locomotives. The greatest number killed and injured were on steam-vessels. The causes of explosions, according to English tables, appear to be about evenly divided between bad design, workmanship, and material, and ignorance or carelessness of attendants. A smaller number were attributed to defects arising in course of use. The most frequent and most destructive explosions in England appear to have been in iron-works and mines.

Earthquakes in England.—The earliest earthquake in England of which a record has been made took place in 1101, when, according to William of Malmesbury, the whole country was terrified "with a horrid spectacle, for all the buildings were lifted up, and then again set down as before." The next was in 1133, when houses were overthrown and flames were said to have issued from rifts in the earth. A third shock occurred in 1185, when, according to Holinshed, "stones that lay couched fast in the earth were removed out of their places, houses were overthrown, and the great church of Lincoln rent from the top downward." An earthquake in 1247, by which much property in London was damaged, was preceded for three months by a suspension of tidal movements on the English coast. On April 6, 1580, two shocks occurred, the second of which caused the church-bells to ring, threw some stones from St. Paul's Cathedral, leveled a part of the Temple Church, caused the death of two worshipers in Christ Church, by the falling of a stone from the roof, and threw a part of the cliff of Dover into the sea. Excitement prevailed for weeks afterward, business was seriously affected, riots were frequent, and prayers were prepared to be offered night and morning for protection against further convulsions. Two undulatory movements of the earth, lasting together about four seconds, took place at noon on September 8, 1692, causing a great panic, but not inflicting very serious damage on property. A slight but evident shock, accompanied with a "great roaring," took place on February 8, 1750, when bells were rung, "dogs howled, and fish jumped

high out of the water." A month later, the people were awakened between one and two o'clock in the morning by a series of shocks. A frantic terror, causing neglect of domestic concerns, riot, and a suspension of business enterprise, possessed all classes for several weeks afterward. It was heightened by a prediction that a third earthquake would occur in April, and all who could left the city; others spent their nights out of doors. A quack made his fortune during the panic by selling pills which he warranted to be a sure preservative against injury by earthquakes. Only slight shocks have since been felt in the metropolis.

Impure Air and Disease.—Dr. J. Ward, health-officer of an English sanitary district of considerable extent and population, has given in the "Sanitary Record" an account of a large number of instances which have come under his immediate observation, in which impure air, arising either from defective ventilation or noxious surroundings, has appeared to be directly associated with the production of diseases of the lungs and other organs. Of eight fatal cases of pneumonia occurring within a year among children and persons in middle life, in all but one the air was defiled from some neighboring source of filth. In about ninety fatal cases of diseases of the respiratory organs, other than pulmonary consumption, most of which were acute or subacute, undoubted defects of ventilation existed. In some cases there was no fireplace or air exit in the room; in some, such opening, where it had existed, had been closed tight; in some the bed, with many in it, was in a close corner; in others the air was defiled by some neighboring household or farm nuisance. Similar defects were observed in nearly all of thirty cases of disorders of the lungs following measles; in forty cases following whooping-cough—in sixteen of which last, "filth influence from immediately contiguous byre, pig-styes, stable, water-closet, or sewer, was noticed." The sanitary investigation of the interior and surroundings of houses where inflammatory affections of the brain have occurred has forced upon Dr. Ward the conclusion that diseases of this class are also frequently, and, it may be inferred, causatively, associated with similar insanitary conditions. In twenty-eight fatal cases of this nature, seventeen cases of tubercular meningitis, and twenty-two cases of convulsions in children, the air was either confined or polluted. Dr. Ward draws from these observations the obvious lesson that it should be the aim of sanitary administration to secure for each habitable room, especially in the crowded cottages of the poorer classes, some suitable provision for a constant change of air. Particularly should care be taken in fixing the position of the bed so that it shall not be in a close corner remote from the influence of the door, window, and fireplace, but should be near some opening through which a constant circulation may be relied upon. In transforming old houses, the provision of fresh air, now neglected and too often prevented in the arrangement of the partitions, should be carefully looked after—else the sanitary condition of the house may be made worse than it was before.

An Improved Filtering Apparatus.—Some experiments that have lately been made in France on the working of the Farquhar apparatus for filtering sewage have been attended with quite satisfactory results. One of the chief obstacles to the purification of foul waters by filtration has arisen from the accumulation of an impervious, slimy deposit on the matter which prevents the liquid from reaching the filtering surface. The Farquhar apparatus is designed to obviate this difficulty by means of a provision for the continuous removal of the slime. The filter-bed, which may be composed of any suitable material, is contained in a closed cylinder in which is worked a cutter-plate continually scraping off the top of the deposit. The liquid to be filtered is forced in through a hollow in the screw-spindle by which the cutter-plate is worked, direct to the underside of that instrument, where it is uniformly distributed over the surface of the filter-bed. The cutter-plate is caused, by suitable machinery, to revolve during the process of filtration, and may also be made to descend if that is desired. The accumulating deposit is scraped off, and forced up the inclined plane of the knife, as shavings are forced up through a carpenter's plane, to

the upper surface of the cutter-plate. By this operation a new clean surface is constantly produced on the filter-bed, practically starting a new filter, at each revolution of the cutter-plate. A model machine, when tried with common sewer-waters at Asnières, near Paris, having a filter-bed of 9⅞ inches in diameter, filtered eight litres, or 1·761 gallons, in a minute under a pressure of one atmosphere and a half. In the same proportion the rate of filtration with a bed one foot in diameter would be 3·31 gallons a minute, and with a bed ten feet in diameter 260 gallons a minute, or 374,400 gallons a day of twenty-four hours. Applied to the water-supply of towns, a machine having a filter-bed ten feet in diameter should filter, under a pressure of one atmosphere, 466,560 gallons in twenty-four hours.

Origin of Diphtheria.—The observations of Mr. G. H. Fosbrooke, medical health-officer of Birmingham, England, have led him to form conclusions respecting the etiology of diphtheria which differ in some points from those which have been urged by other authorities. He regards it as a well-established fact, confirmed by his experience, that the disease is more common in rural than in urban districts, and has observed that even when it has prevailed extensively in a rural district, and has thence been conveyed into a neighboring town, it has not spread in the town. In one town of five thousand inhabitants, diphtheria, when it occurred, prevailed concurrently with typhoid fever or scarlatina, giving rise to the suggestion that all those diseases might originate in a common poison. Mr. Fosbrooke does not agree with other authorities as to the conditions of soil most favorable to the propagation of diphtheria. Generally the disease has been thought to flourish most in damp situations and in connection with damp subsoils. All of his attempts to associate its origin and distribution with any peculiar soil or situation have failed, for he has met it both in villages occupying elevated and airy situations and in low places. The most serious epidemics and the larger number of cases of which he has had personal knowledge have appeared on soils that were "rather gravelly and well drained." With one exception, his experience opposes the idea that houses shut in by trees are more liable to harbor the disease than those which are not surrounded by an abundant vegetation. The fluctuations of diphtheria, when it prevails for any considerable length of time, do not appear to be influenced by changes of season or by variations of weather. Meteorological observations, made with reference to this point, differ widely, and furnish no guide to an opinion. The disease is generally found first to break out in October, and to prevail as an epidemic, when it does so prevail, in the winter months, increasing, as is natural with epidemics, during the earlier months of its course, but without regard to the regularity or irregularity of the season.

Anthropology in Russia.—Anthropology has made much progress in Russia. The Imperial Society of the Friends of Natural Science, Anthropology, and Ethnography, founded in 1863, of which Bogdanof is the master-spirit, has done good service in assuming the patronage of investigations among the numerous diverse stocks of whom the Russian nationality is composed, and in encouraging measures to bring the interests of anthropology before the public. The Anthropological Exhibition, which was held at Moscow last summer, had this object prominently in view, and was further intended to promote the establishment of a professorship of anthropology, and of an anthropological museum. The collections exhibited and reported upon embraced skulls, skeletons, relics, prehistoric and modern, and articles of various kinds, illustrating the character, condition, and customs of the ancient and modern inhabitants of the empire. Among the neolithic stone implements from Kazan were hatchets, crossed by a groove in which to fasten the handle, precisely as in the North American hatchets, and arrow-heads, both with and without shafts. Fragments of urns bearing the well-known pack-thread ornament and bronzes of the so-called Tschudic type were shown from the Volga. Filimonof brought from the Caucasus, where he has been digging under the auspices of the society, great bronze whorls, of similar form to those which are met in the Baltic provinces, but

larger, fibulæ, precisely like those of the *terra mare* of Italy, but to which nothing similar has been found between the two places, and Etruscan potteries. These articles are probably of the sixth century B. C., and relics of Italian colonists. A splendidly ornamented bronze hatchet, from the same region, also deserves mention. Filimonof has concluded, from the researches he has made, that the transition from bronze to iron took place in the Caucasus about five hundred years before Christ. Bronze buckles from near Kertch, like those of the Merovingian period in France, were probably Roman. Craniology was fully represented by more than five hundred Kurgan skulls, and by a host of skulls representing about twenty races of Europe and Asia. Among the numerous skeletons were two of Ainos. A skull of the stone age from the government of Vladimir and pieces of other skulls and skeletons found with it are the oldest remains of man yet found in Russia, and the first of the stone age. Professor Inostranzof, of St. Petersburg, has recently found other human remains of that age. The ethnographic department was not so fully represented as the others, but included collections illustrating the various modes of caring for infants, embroideries, articles of household manufacture, models of houses and farm-buildings, musical instruments, hunting, fishing, and farming implements, and rare articles representing the diversified populations of Siberia, the last being contributed by the Imperial Russian Geographical Society of St. Petersburg. This department is richly illustrated in the collection of the Rumyanzof Museum, of Moscow.

The Phæodaria.—Professor Ernst Haeckel, at a recent meeting of the Natural History Society of Jena, read a note on the phæodaria, a new group of marine siliceous rhizopods, rich in specific forms and remarkable in many respects, which have hitherto been included in the typical radiolaria, from which, however, they present considerable points of difference. A new light has been thrown upon these beings by the Challenger Expedition, which, besides discovering forms of typical radiolaria corresponding to two thousand species, brought to light a number of deep-sea phæodaria, hitherto entirely unknown. John Murray, in 1876, described some of the forms of these new species, drawing attention to the extremely delicate and finely fenestrated structure of the large siliceous shells, and to the constant appearance of masses of black-brown pigment which are scattered through the sarcode, outside the central capsule. These animals are usually considerably larger than the other radiolaria, and many of them are visible to the naked eye. They bear a peculiar mass of dark pigment-granules, called pheodium, outside the central capsule, and have, with few exceptions, a well-developed, always extra-capsular, siliceous skeleton, which forms very varied and delicate structures, usually radiating outward in hollow siliceous tubes.

Industrial Accidents, etc.—Mr. T. A. Brocklebank suggests that the amount of sickness and death incurred in industrial operations in England, as a direct result of the conditions under which they are carried on, is a subject that demands investigation. In 1877 he compiled tables for use before the House of Lords, which gave returns of deaths and injuries by boilers in mines, on railways, and at factories, with totals for 1873, 1874, 1875, and 1876, of 107,000 men, women, and children; and he estimates, on the basis of the facts contained in these tables, that 500,000 workmen will be killed during the ten years, 1877 to 1886, as follows: in mines, 300,000; on railways, 70,000; in factories, 180,000. Sir Edward Watkin also has made a statement in the House of Commons to the effect that 100,000 persons are killed annually in industrial occupations in England. Facts are cited to show that the accidents that are reported compose only a part of those which take place, and to make it appear probable that Mr. Brocklebank's estimate is a very moderate one.

Sewage-Farming.—The Royal Agricultural Society has recently awarded two prizes of one hundred pounds sterling each for the best managed sewage-farm, the one utilizing the sewage of not more, the other that of more than twenty thousand people. Nine farmers competed for the two prizes. The judges stated in their report that there was a very considerable difference, both in the

amount of capital engaged upon the several farms, and in the gross returns per acre. The gross returns and the amount of wages paid per acre were greatest in cases where market-gardening was in vogue. It was remarked that a large area of ordinary agricultural land attached to a sewage-farm does not always add to the profit of the undertaking. Statistical tables showing the number of persons living or working on the farms, and the number of children on them, make it appear that the average annual mortality upon them does not exceed three per thousand, and that "sewage-farming is not detrimental to life or health." About one hundred sewage-farms are in operation in England.

Habits of the Green Lizard.—Sarah P. Monks has contributed to "The American Naturalist" an interesting study of the habits of two green lizards, or American chameleons, which she has kept in her rooms. The first, a female, came from South Carolina in November, and was kept in a room warmed with a furnace. It was very lively and ran about a great deal during the winter, but paid no attention to the flies till the warm spring-days came, when it greedily devoured them and eagerly lapped water with its tongue. When a male lizard was put in the cage in May, a curious ceremonial courtship took place between the pair, each animal raising itself to the full extent of its forelegs and bowing its head and the forepart of the body in a regular and dignified manner as if it had a hinged joint at the shoulder. Both lizards would scamper off when they found that their actions were observed; and, if a fly came near them, they would dart after it "like a flash of green light." The changes of color in the creatures were frequent and marked, but the observations upon them were contradictory and unsatisfactory. The changes were different in the two specimens: the same causes did not affect them both alike; and the changes came on without regard to the object on which they were placed, or to the amount of light and darkness. They would become green or light-brown when placed in sunlight, but would also assume the same colors in the darkest room. When disturbed they would sometimes become darker, but at other times would not change. The changes were rapid, taking place in from two to eight minutes; and at one time one of the lizards changed from green to light-brown, then back to green again, in five minutes. They would go to sleep as soon as it became dark, and in the gloom of a storm, and would wake again on the appearance of the sun, although they were not exposed to its direct rays. They assumed various positions in sleeping—sometimes, when it was cool, lying close up under a bit of loose bark, sometimes curled in a corner behind a small jar, sometimes stretched out on a limb or along the twigs. When in a crevice or hole, they took any shape that was convenient, but on sticks and twigs they arranged themselves so as to imitate the general form of the branches. The changes of the skin do not appear to depend upon any particular time or season, but upon the general health and growth of the animal. One of the lizards changed twice in seventeen days, the other only four times in five months. The skin split along the back and the upper sides of the legs, and came off in large fragments. The lizard would seize a bit in his mouth and pull it off as if it were an inverted glove, and would then eat it. The bits of skin that remained around the jaws and eyes seemed to annoy the animal very much. When the tail had been broken off and renewed, as was the case with one of the lizards, the exuviation of that part took place independently of the rest of the body.

The Safe Manufacture of Dynamite.—The French Academy of Sciences has recently awarded a prize of twenty-five hundred francs to Messrs. Boutmy and Foucher for introducing new modes of producing nitro-glycerine in quantity, by means of which the manufacture of dynamite has been rendered much safer than it has heretofore been. The old method, in which fuming nitric acid, or a mixture of that substance and sulphuric acid, was made to act on glycerine, and the mass was suddenly immersed in water, often resulted in the production of enough heat to decompose a part of the nitro-glycerine, and occasion a violent explosion in spite of the best refrigerating processes that could be employed. The principle of the new process consists in

obviating the greater part of the heat by first engaging the glycerine in a combination with sulphuric acid, which forms a sulpho-glyceric acid, and then destroying this compound slowly by means of nitric acid. Two liquors are prepared in advance—a sulpho-glyceric and a sulpho-nitric liquor (the latter with equal weights of sulphuric and nitric acids). These disengage a considerable amount of heat; they are allowed to cool, and are then combined in such proportions that the reaction takes place slowly. In the old method the nitro-glycerine is separated almost instantaneously, and rises in part to the surface, rendering washing difficult; in the new method it forms in about twenty hours, with a regularity which prevents danger, and goes to the bottom of the vessel, so that it can be washed rapidly. In the works of Messrs. Boutmy and Foucher at Vouges, where the new process has been employed, no life has been lost for six years, and the general health has been excellent.

NOTES.

THE annual meeting of the National Academy of Sciences was held in Washington, D. C., beginning April 19th, under the presidency of Professor W. B. Rogers, of Boston. The sessions continued through four days, and were marked by the reading of a large number of papers, of general as well as special interest. None of the papers received more attention than that of Professor Bell concerning his later experiments in the production of sound by radiant energy, which we publish. Professor Barker, in his paper on "Incandescent Lighting," also touched a subject which engages general interest. The papers of Professor Pumpelly, on the relation of soils to health, of Professor Morse, on the utilization of the sun's rays in heating and ventilating, and others, show that the Academy does not neglect practical subjects. Mr. W. H. Dall gave an account of the "Land Ice in Kotzebue Sound," of which mention has already been made in the "Monthly"; and Professor T. Sterry Hunt described the "Auriferous Gravels of California." President Garfield visited the Academy, and was warmly welcomed. The meeting was more than ordinarily interesting.

THE Boston Society of Natural History announces that a seaside laboratory, capable of accommodating only a limited number of students, will be open under the direction of its curator, Alpheus Hyatt, at Annisquam, near Gloucester, Massachusetts, from June 5th to September 15th. As the purpose is simply to afford opportunities for the study and observation of common types of marine animals under suitable direction and advice, no attempt will be made to give any stated course of instruction or lectures. The work will be adapted to meet the wants of those who have already made a beginning in the study of natural history. The apparatus will consist of the simplest laboratory furniture, collecting instruments, and row-boats, and a yacht for dredging excursions after the latter part of July.

ACHILLE DELESSE, an eminent French geologist, died March 24th. He was engaged through most of his life as a mining engineer, and was at one time Professor of Geology and Mineralogy at Besançon, and at another Professor of Agriculture, Drainage, and Irrigation in the École des Mines. He was author of works on some of the mineralogical features of the Vosges, of "Researches on the Origin of the Rocks," geological and hydrological maps of the city of Paris, and the rainfall of Paris, and, in conjunction with MM. Langel and De Lapparent, issued for twenty years the annual "Revue de Géologie." He was for two years President of the Geological Society of France.

"NATURE" doubts whether our Fish Commissioners will be able greatly to increase the yield of sea-fish, like shad, herring, and cod. The arguments of Malthus respecting the relations between food-supply and the increase of population are thought in England to be applicable to fish. "Sea-fish, like all other animals," it says, "are undoubtedly increasing in greater proportion than their food; and it is obvious, therefore, that, unless man can increase their food, it is only lost labor to increase their number."

FANNY, a very aged carp in the ponds at Fontainebleau, well known to the people of Paris, has just died. She is said to have been hatched during the reign of King Francis I, and had become very gray.

THE sixth session of the Summer School of Biology of the Peabody Academy of Science, Salem, Massachusetts, will commence July 12th, and continue for four weeks. Instruction designed especially for teachers. Further information may be obtained from Professor Edward S. Morse, of Salem.

MR. WILLIAM PEARCE, of the Clyde shipbuilding firm of John Elder & Co., has stated, in a lecture on recent improvements in marine navigation, that the first steamers of the Cunard Company, in 1840, were under contract to go 8½ knots an hour; were of 740 horse-power; and consumed 4 1/10 pounds

of coal per horse-power. The Persia, built in 1856, had side-lever engines, indicating 3,600 horse-power, and consumed 3 $\frac{7}{10}$ pounds of coal per horse-power. The Gallia, built in 1879, was fitted with compound engines of 5,000 horse-power, and sailed with a speed of 15½ knots an hour. The Persia burned 6½ tons of coal for every ton of cargo it carried; while the Gallia burned less than half a ton, although it carried the cargo 2½ knots an hour faster than the Persia. The Arizona, with 6,000 horse-power, consumed 1¾ pound of coal per indicated horse-power, and carried 3,400 tons of cargo at an average speed of 16½ knots, burning less than four hundred-weight per ton of cargo at a speed across the Atlantic faster than any previously recorded.

Dr. Hiram A. Cutting, of Vermont, has made a series of examinations into the durability under heat of different kinds of granite, sandstone, limestone, marble, conglomerate, slate, soapstone, and artificial stone. Granite began to yield at a temperature of between 700° and 800°; it became cracked between 800° and 900°; generally cracked between 800° and 950°; and was made worthless by or before reaching a temperature of 1,000°. Sandstones showed a greater power of endurance, massive limestones still greater, and marbles the greatest, while conglomerates seem to have been among the weakest stones. The least absorbent and the most absorbent of the granites were equally the granites most destructible by heat.

The annual meeting of the Society for the Promotion of Agricultural Science will be held at Cincinnati, August 16th, the day before the meeting of the American Association for the Advancement of Science. Papers will be presented by Professor W. J. Beal, on "Testing Seeds"; by Professor R. C. Kedzie, on "The Ripening of Wheat"; and other essays, the subjects of which have not been announced, will be read by Professor S. W. Johnson, Patrick Barry, Professors J. H. Comstock, E. W. Hilgard, and A. J. Cook, Messrs. J. J. Thomas, L. B. Arnold, and E. Lewis Sturtevant, M. D.

The meeting of the French Association for the Advancement of Science at Algiers was successful in point of numbers, at least, notwithstanding the troubles with Tunis. A great many members had arrived on the 11th of April, fresh ones were coming in every boat, and it was thought that the attendance would exceed a thousand.

Professor James Tennant, F. G. S., a well-known mineralogist, has recently died in London, at the age of seventy-three years. He was the possessor of one of the largest and most valuable collections of minerals, was for many years Professor of Geology and Mineralogy, afterward Professor of Mineralogy in King's College, London; he held the office of "Mineralogist to the Queen," and was consulted by the Government, as one of the best authorities on gems, with respect to the cutting of the Koh-i-noor diamond. He did useful work in preparing collections of minerals and fossils suitable for educational purposes and as a lecturer, and was author, in connection with the late Professor Ansted and the Rev. W. O. Mitchell, of the treatise on "Geology, Mineralogy, and Crystallography" in Orr's "Circle of the Sciences."

The death is reported of Mr. F. A. Nobert, the celebrated producer of test-plates for miscroscopists. He had been engaged for many years in ruling micrometers and diffraction plates, and produced one set of lines—his nineteenth band—equivalent to about 112,000 lines to the inch, which he believed could never be seen resolved in the microscope. Dr. Woodward eventually produced photographs of the finest of these lines; when Mr. Nobert ruled a new plate, the finest band of which—the twentieth—was of a fineness equivalent to about 224,000 lines to the inch.

The New York Electrical Society was formed in this city on the 8th of February last, with the purpose of bringing persons engaged in operations connected with electricity into closer connection and association with each other for improvement in knowledge of electric art and science, and for social intercourse. The first regular meeting of the society was held on the 2d of March, when the organization was completed. Its real work was begun at the meeting of March 16th, when a paper was read by Mr. F. W. Cushing on the "Harmonic Telegraph" of Professor Elisha Gray. The preliminary meeting was participated in by between thirty and forty electricians and telegraphists: more than two hundred members had been enrolled at the meeting of March 16th.

Sir Philip Egerton, Bart., M. P., one of the Vice-Presidents of the Geological Society, died in London, April 5th, in the seventy-fifth year of his age. He was chosen a Fellow of the Geological Society in 1829, and a Fellow of the Royal Society in 1831, and was also a Fellow of the Society of Antiquaries, antiquary to the Royal Academy, trustee of the British Museum, and one of the senate of London University. He was the author of fifty-one scientific papers, chiefly devoted to studies of fossil fishes, and generally published in the journal of the Geological Society, besides several papers in which he was joint author with other persons. He was owner of a collection of fossil fishes of remarkable value, it being but little inferior to that of the Earl of Enniskillen, which is, perhaps, the finest in the world.

CHARLES THOMAS JACKSON.